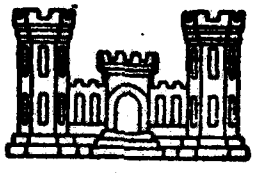
LEVEL II

BRONX RIVER BASIN

(3)

KENSICO DAM
WESTCHESTER COUNTY NEW YORK
INVENTORY NO. 51

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM



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For: THE STATE OF NEW YORK

Date: MAY 1978

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Westchester County
White Plains

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides information and analysis on the physical condition of the dam as of the report date. Information and analysis are based on visual inspection of the dam by the performing organization.

The Kensico Dam is maintained in excellent operational condition by City of New York Personnel. The dam, spillway and pertinent works exhibit no evidence of distress and is stable for all anticipated conditions.

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Kensico Reservoir is unique in that the major source of inflow, and regulation of discharge and impoundment, are a function of the aqueduct system rather than the contributing watershed area; which is relatively small. As such it has been determined that the Kensico Dam Spillway can safely discharge the probable maximum flood.

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BRONX RIVER BASIN - KENSICO DAM

INVENTORY NO. 51

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A P P E N D I X

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	KENSICO DAM
State Located:	NEW YORK STATE
County Located:	WESTCHESTER COUNTY
Stream:	BRONX RIVER
Date of Inspection:	12 JANUARY 1978

ASSESSMENT

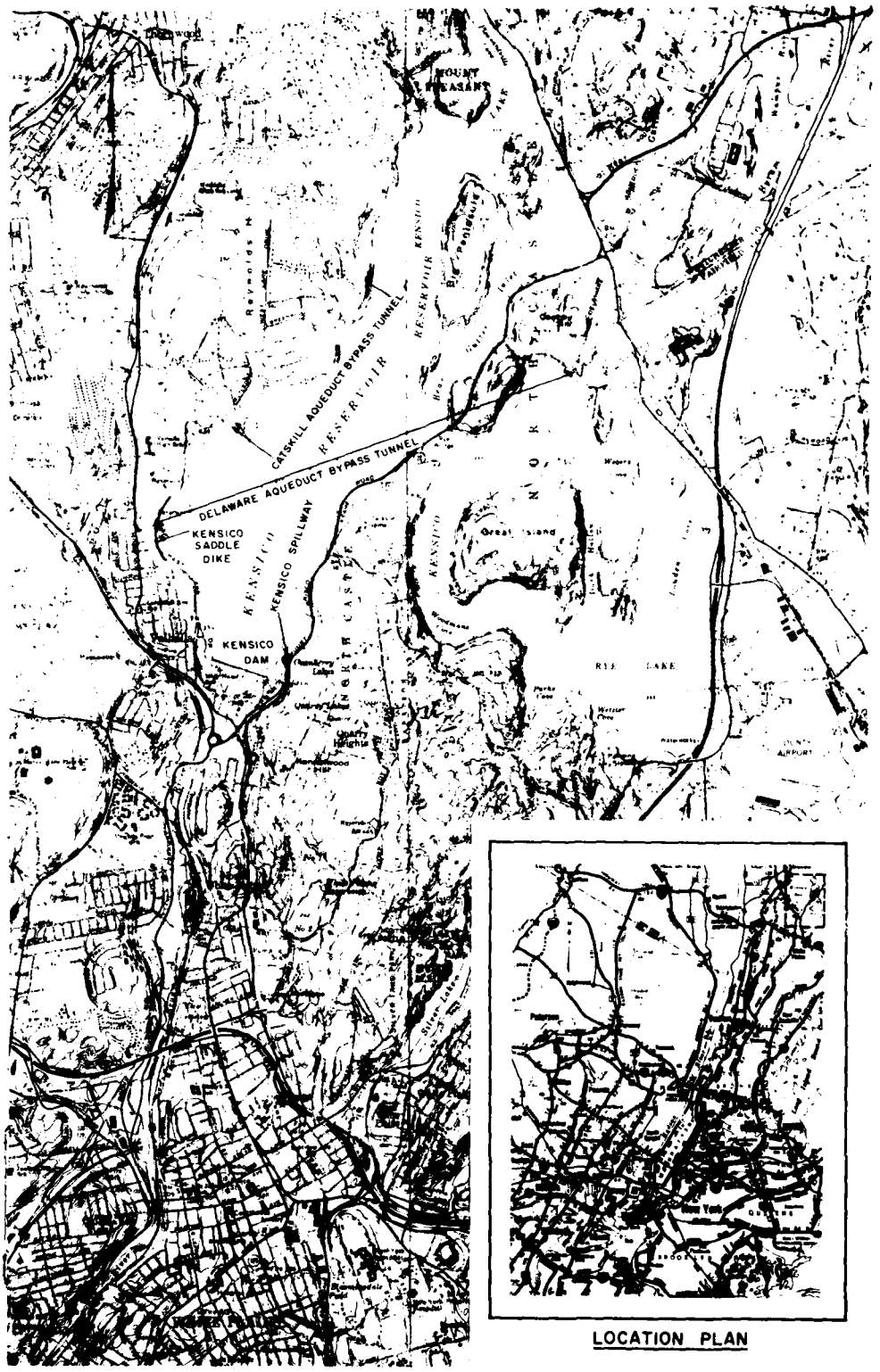
The visual examination of Kensico Dam and the examination of pertinent available plans and documents revealed no detrimental findings to render an unsafe assessment.

The dam is maintained in excellent operational condition by City of New York personnel. The dam, spillway and pertinent works exhibit no evidence of distress and is stable for all anticipated conditions.

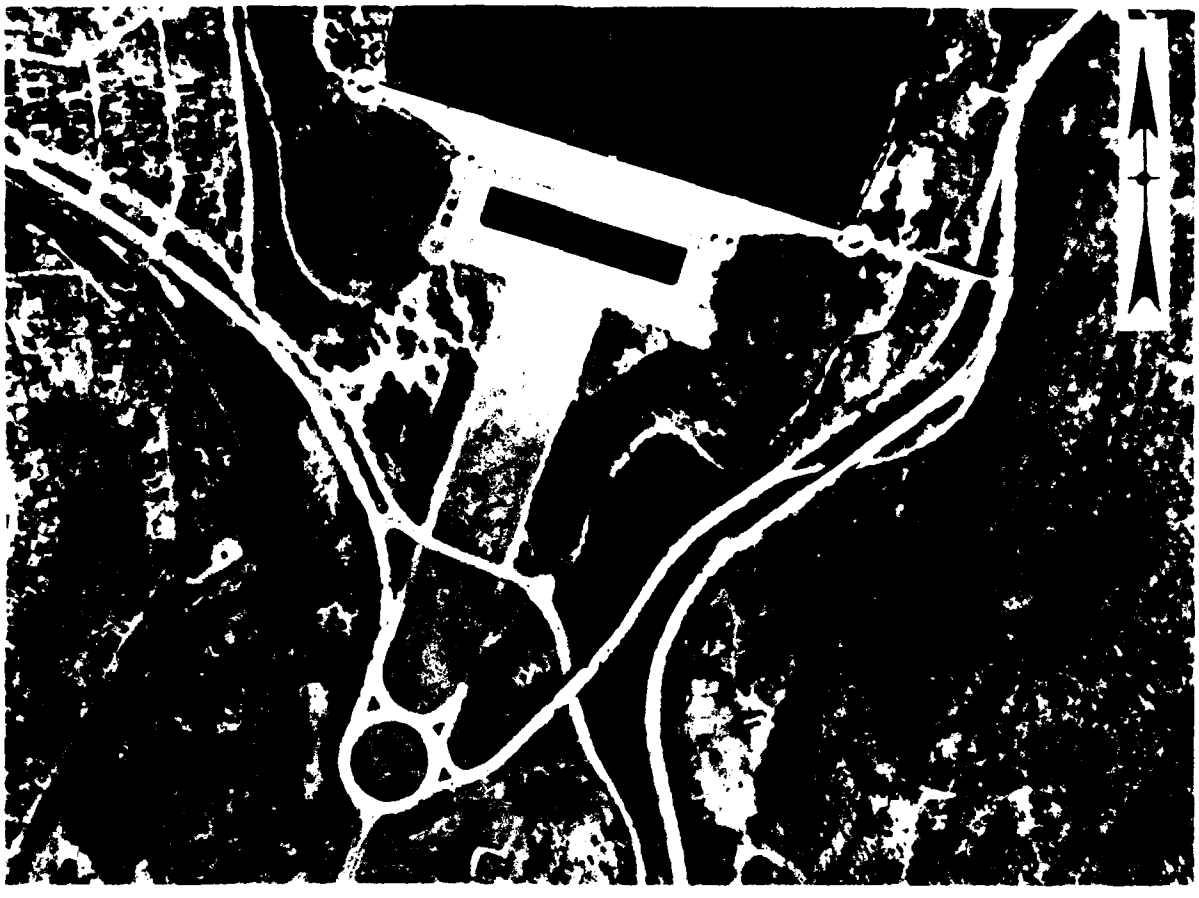
Kensico Reservoir is unique in that the major source of inflow, and regulation of discharge and impoundment, are a function of the aqueduct system rather than the contributing watershed area; which is relatively small. As such it has been determined that the Kensico Dam Spillway can safely discharge the probable maximum flood.

Approved by: Clark H Benn
CLARK H. BENN
Colonel, Corps of Engineers
District Engineer

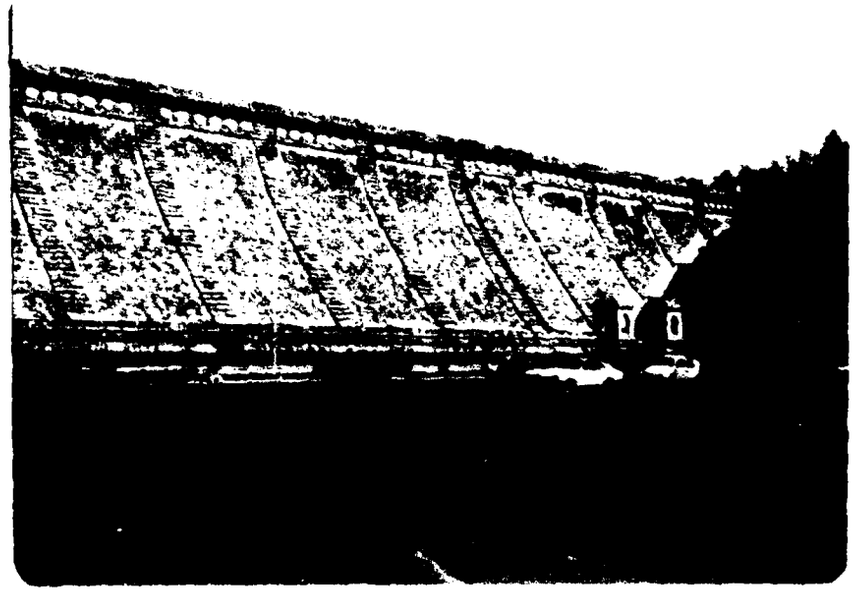
DATE: 7 June 1978



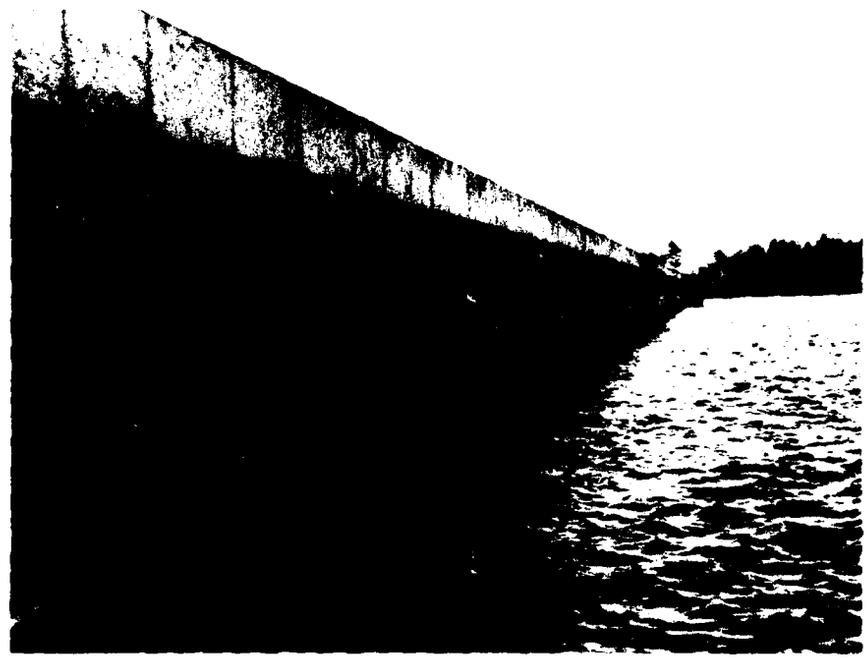
VICINITY PLAN



KENSICO DAM
OVERVIEW PHOTO



DOWNSTREAM FACE KENSICO DAM



UPSTREAM FACE KENSICO DAM

LOWER GALLERY AND DRAINAGE WELL

CRACK AT DRAINAGE WELL
UPPER GALLERY

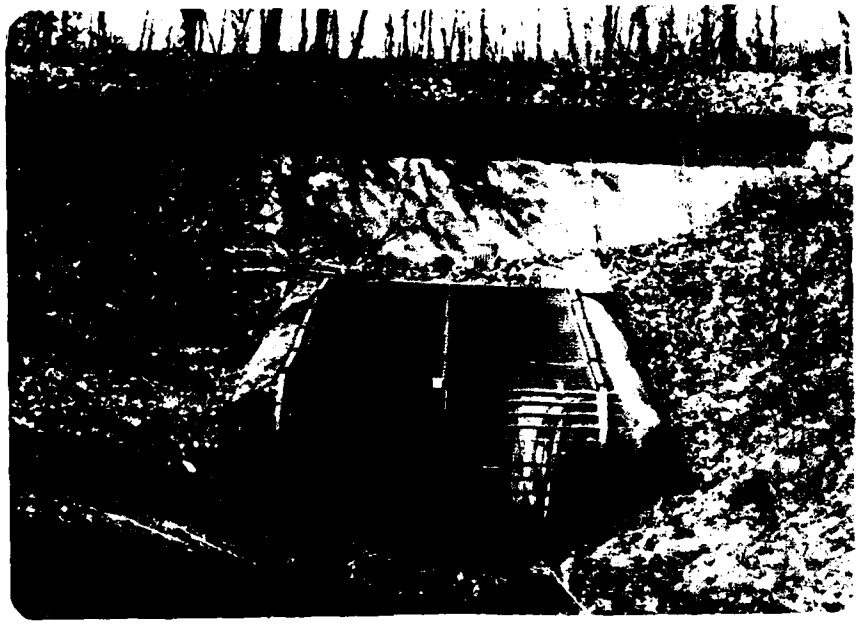
CRACK AT UPPER GALLERY

DOWNSTREAM SLOPE KENSICO SADDLE DIKE

DOWNSTREAM FACE KENSICO SPILLWAY

UPSTREAM FACE KENSICO SPILLWAY

DOWNSTREAM CHANNEL KENSICO SPILLWAY



ENTRANCE TO OUTLET TUNNEL
DOWNSTREAM CHANNEL KENSICO SPILLWAY

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
KENSICO DAM I.D. No. 51

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

a. Authority. Authority for this report is provided by the National Dam Inspection Act, Public Law 92-367, 1972.

b. Purpose of Inspection. Evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

1.2 DESCRIPTION OF PROJECT:

a. Description of Dam - Kensico Dam was constructed during the period 1910-1916 to contain an emergency reserve of Catskill water sufficient to maintain the supply to the City of New York in the event of a shut-down of either the Catskill or Delaware aqueduct systems, supplying water from up-state reservoirs. The reservoir is formed by the Kensico Dam across the valley of the Bronx River about three miles north of White Plains, Westchester County, New York. An earth saddle-dike, approximately 1500 feet long and attaining a maximum height of approximately 30-35 feet impounds the west side of the reservoir just north of Valhalla. The main dam has a crest length of 1843 feet, a top width of 28 feet and a maximum width at the foundation of 235 feet. Its maximum height above the foundation is 307 feet and 168 feet above natural grade. The dam is constructed of cyclopean concrete, and is faced on the upstream side with massive precast concrete blocks. On the downstream side, the concealed part of the face was moulded against wooden forms, and the exposed part was faced with cut-stone masonry. Transverse expansion joints divide the dam into sections approximately 79 feet long. Integral with these joints are copper water stops and a system of drainage wells, which convey both surface water from atop the dam and water percolating through the joints to the lower inspection gallery from which it is discharged through a covered waste channel into the Bronx River below the dam. Two inspection galleries are constructed in the dam near the upstream face; the upper just below the top of the dam and the lower near the level of the reservoir bottom. The drainage wells are formed of hollow blocks of porous concrete, spaced 15 feet apart longitudinal and connecting between the upper and lower galleries. A public highway traverses the top of the dam. Water from the Catskill Aqueduct enters Kensico Reservoir at its north-westerly end. Delaware water enters the reservoir on the easterly side. Both Catskill and Delaware water are drawn from the reservoir on the west side at a point about one mile north from Kensico Dam and approximately 2½ miles from the point of entry of each. Diversion tunnels allow the by-passing of either Catskill or Delaware water from the reservoir system. A concrete spillway 50 feet long with permanent flashboards set at elevation 357 feet MSL is located just east of the main dam at the southerly portion of the reservoir. Regulation of the level of impoundment is performed at the influent and effluent gate houses and the spillway has not spilled water since 1 July 1922.

b. Location - The Kensico Dam (I.D. No. 51) is located approximately three miles north of White Plains, Westchester County, New York. The latitude is 41°-4.9' and the longitude is 73°-46.2'.

c. Size Classification - Storage is in excess of 38,000,000,000 gallons and the impoundment covers 2,218 acres. The crest of the dam is 307 feet above the lowest foundation level and 168 feet above existing grade. Based upon the above the dam size is classified as large.

d. Hazard Classification - Based upon the dam being located within a heavily populated area, New York State Department of Environmental Conservation has classified the Kensico Dam as a Hazard Category I structure.

e. Ownership - Kensico Dam and Reservoir is owned by the City of New York.

f. Purpose of Dam - Kensico Dam and Reservoir was designed and constructed to contain a large quantity of Catskill water for supplying the City of New York in the event the supply from the upstate New York reservoirs should be cut-off for inspection or repairs of the aqueduct system. The available storage, approximately 29 billion gallons was sufficient to supply the whole City of New York at the rate of consumption of the year 1920 for more than one month.

g. Design and Construction History - The Kensico Dam was built during the period 1910-1916 under the direction of the Board of Water Supply of the City of New York. J. Waldo Smith was Chief Engineer and John R. Freeman, Prof. William H. Burr, Frederick P. Sterns and Alfred Noble were Consulting Engineers. The impoundment behind the dam submerged the old Kensico Dam and Reservoir which was constructed in 1880-1885 and yielded a supply of approximately 18 million gallons per day through the Bronx Water Line from the watersheds of the Bronx and Byram Rivers.

1.3 PERTINENT DATA:

a.	Drainage Area	12.8	square miles
b.	Discharge at Damsite		
	Maximum known flow over spillway (1 July 1922).	80	CFS
	Warm water outlet at normal pool elevation.	800	CFS
	Spillway capacity at top of dam elevation.	7,500	CFS
c.	Elevation (above MSL)		
	Top of dam	370	feet
	Maximum pool elevation	357	feet
	Full flood control pool	357	feet
	Recreation pool	N/A	
	Spillway crest (with perm. flashboards)	357	feet
	Natural streambed		

d. Reservoir

Length of maximum pool	5.63	miles
Length of recreation pool	N/A	
Length of flood control pool	5.63	miles

e. Storage

Recreation pool	N/A	
Flood control pool	93,780	acre-feet
Surcharge	22,780	acre-feet
Top of dam	116,560	acre-feet

f. Reservoir Surface

Top of dam	2,600	acres
Maximum pool	2,220	acres
Flood control pool	2,220	acres
Recreation pool	N/A	
Spillway crest	2,220	acres

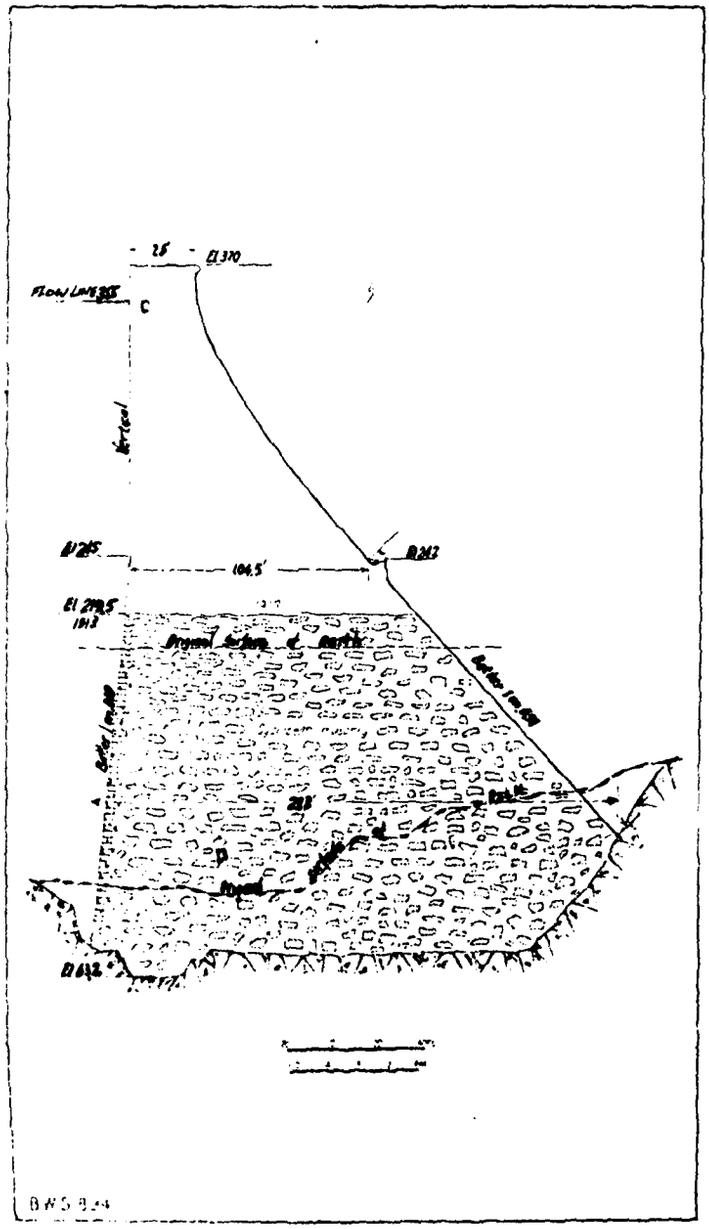
g. Normal Operational Procedure - To maximize its efficiency as a storage facility, it is desireable to maintain a high normal pool elevation on Kensico Reservoir. The pool elevation is read daily by the staff of the Bureau of Water Supply under normal conditions. During periods of concern, the elevation gages are read hourly. Whenever possible, the pool elevation is maintained at .5 feet below the spillway crest. Fluctuations in pool level are not adjusted by either spillway discharges or blow-off discharges at the dam. Reservoir stage is maintained by regulating the inflow from the Catskill and Delaware Aqueducts (combined capacity of 1600 million gallons per day), or, by regulating the intake for the continuation of the aqueducts downstream of the reservoir (combined capacity of 2225 million gallons per day). The aqueduct out-take from the the reservoir is a function of the daily requirements of Hillview Reservoir, the next link in New York's Water Supply System. Regulation of the Catskill Aqueduct flow into Kensico Reservoir requires a 14 hour time lag. Regulation of the Delaware Aqueduct flow is instantaneous. The 48 inch diameter "Bronx Line" outlet is in constant use. Discharges from this conduit supply several Westchester County holding tanks and local consumers with their daily water needs. Routine inspection of the dam, outlet works, and aqueduct intakes is performed regularly.

h. Spillway

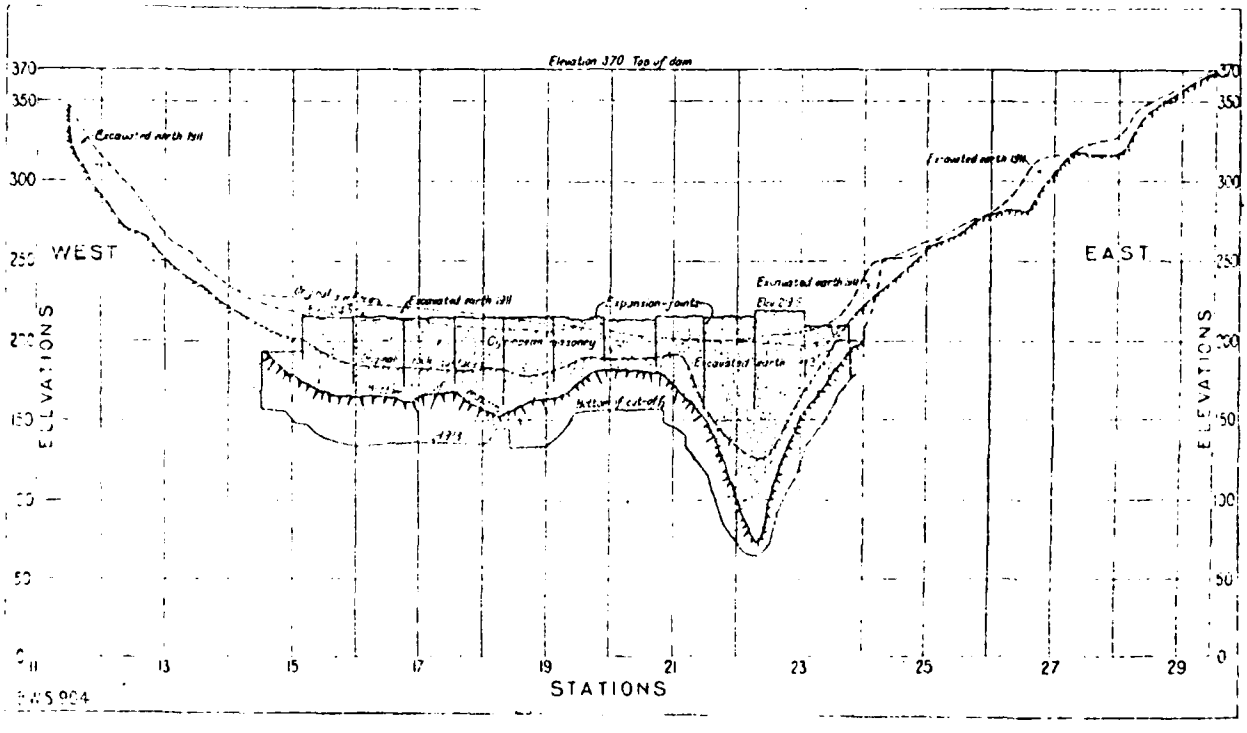
Type	- Concrete ogee spillway
Weir length	- 50 feet
Crest elevation (without flashboards)	- 355 feet above MSL
Crest elevation (with permanent flashboards)	- 357 feet above MSL
Upstream channel	- Paving and crushed stone over an earth embankment.
Downstream channel	Mass concrete channel for 34 feet, then paving stones over earth.

i. Regulating Outlets - For the purpose of lowering the pool elevation, a 10 foot diameter blow-off leading to a 60 inch conduit is provided. In addition to the 60 inch conduit, there is a 48 inch diameter "Bronx Line" which is in constant use. Its discharge capacity is minimal in its effect on reservoir pool elevation. The effectiveness of the main conduit of the blow-off has never been tested. The aqueduct is the most efficient regulatory agent.

j. Diversion and Regulating Tunnel - The bulk of the outflow from Kensico Reservoir is diverted to the Catskill and Delaware Aqueducts. The aqueducts' intake systems are nominally capable of withdrawing 2225 million gallons per day. With the inflow aqueducts not discharging into the reservoir, the effluent structures are capable of lowering the pool elevation two feet per day. The water, thus diverted, procedes along the aqueduct to the Hillview Reservoir and eventually to consumers in New York City.



KENSICO DAM MAXIMUM CROSS - SECTION



KENSICO DAM LONGITUDINAL SECTION
ACROSS BRONX RIVER VALLEY AT DAMSITE

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

Design computations for Kensico Dam are not available, however, engineering principles governing the design of Kensico Dam and other similar dams built during the same period under the auspices of the Board of Water Supply of the City of New York are outlined in "DESIGN AND CONSTRUCTION OF DAMS" Wegmann, 1927. Plans covering important aspects of the dam are included in Appendix "A". As built drawings are not available.

2.2 CONSTRUCTION:

Construction records are not available for review, however, a fairly detailed construction history of Kensico Dam is contained in "DESIGN AND CONSTRUCTION OF DAMS" Wegmann, 1927. In addition, "ANNUAL REPORTS OF THE BOARD OF WATER SUPPLY", in particular for the year 1913, gives a detailed report of the excavation for the dam. Outlined below is a synopsis of relative information taken from the above.

The excavation of the Kensico Dam was begun in the fall of 1911. The floor of the Bronx River Valley at its lowest point is about 200 feet above sea level. Bedrock at the eastern portion of the valley consists of Fordham Gneiss; at the western portion Manhattan Shist; these two formation being separated by a stratum of Inwood Limestone about 400 feet thick. Overburden consists of 10-30 feet of modified glacial drift. A pre-glacial gorge approximately 250 feet wide at the top and about 120 feet below the floor of the valley exists near the contact of the gneiss and limestone. This gorge naturally divided the excavation and placement of concrete into east and west sections, a separate plant being furnished to service each segment. A cut-off trench 20 feet wide and 20-30 feet deep was excavated into the rock under the upstream face of the dam. The cut-off trench extended below all visible open seams in the rock. The foundation of the dam required extensive grouting at only two points. One at a soft limestone seam approximately 400 feet westward of the center of the gorge and the other at the entire east side of the gorge. Slight springs were noted emanating from small open seams at two or three other locations west of the gorge. At the soft seam in the limestone west of the gorge grout holes, drilled to a depth of 25 feet were tested with water and dye. The small seams west of this area were found to be interconnected. After a concrete cover 35 feet or more in thickness had been placed the area was grouted under a pressure of 100 psi. The area on the east side of the gorge required considerably more grouting. The excavation there had followed the dip of the strata and it was felt that the strata not removed might have been loosened. The side of the gorge was also exposed to summer sun which tended to produce a swelling and thus open up the bedding planes. Several seams were open and water bearing. Grout holes 25 feet deep and 15-25 feet on centers longitudinally was drilled and grouted in stages. First the holes upstream from the cut-off trench, which appeared to interconnect with each other, were grouted; second the holes in the cut-off trench, which evidently penetrated a region not reached by the other holes; and thirdly, all the holes downstream from the cut-off trench, which were interconnected. The grout consisted of one part cement to three parts water. A maximum of 100 psi grout pressure was utilized. The placing of

masonry in the gorge was started in the latter part of 1913 and completed that same year. All excavated material was used in grading the plaza and approaches to the downstream side of the dam. After the gorge had been filled to elevation 152 MSL work proceeded between expansion joints; those joints dividing the dam into sections 79 feet long. The upstream side of the dam above the foundation, and the expansion joints, were faced with precast concrete blocks, which were laid first for each course of masonry, and served as forms for the cyclopean concrete. Timber forms were only required on the downstream side of the dam. All concrete blocks were cast-on-site. The quarry from which most of the stone for the dam was obtained was located one mile east of the dam and was composed of a gneissoid granite. Cutting and crushing of stones were done on location. "Thermopanes" were installed in the cyclopean concrete to monitor temperature rise during set. Nothing unusual was observed.

2.3 OPERATION:

Formal operating instructions were not available. Operation of the influent and effluent gate houses influencing reservoir stage are carefully monitored and maintained by New York City Personnel.

2.4 EVALUATION:

Design plans available agree significantly with actual conditions at the damsite. Sufficient construction information is available in the references stated above to assess the stability of the dam providing the design /construction procedures outlined in the above references were adhered to. Operation of the dam and reservoir was explained verbally at the site by the engineer-in-charge.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

a. General - The Kensico Dam was inspected by the New York District Corps of Engineers and New York State Department of Environmental Conservation personnel on 12 January 1978.

b. Dam - The dam appears to conform to the available drawings with respect to the geometry of the structure. No seepage was noted at the downstream face of the dam or at the abutments and only very minor seepage was noted in the drainage wells and inspection galleries. A portion of the water noted in the drainage wells and observation galleries originates as surface water on the roadway above the dam, being transmitted to the drainage wells through drop inlets and manholes. There is no method for separating this surface water from actual seepage through the masonry and joints of the dam. Total volume of water passing the lower gallery has been measured at 2000 gallons per day. No visual signs of misalignment or structural cracking were observed on either the exterior of the dam or in the inspection galleries or drainage wells. Concrete exposed in the inspection galleries was in excellent condition, no significant cracking or spalling was observed. The downstream face of cut granite is in excellent condition and exhibits no sign of seepage. On the upstream face of the dam the original concrete blocks were found to have deteriorated, probably due to saturation and subsequent freeze and thaw. The deteriorated concrete was found to extend 18-20 inches into the face. Deteriorated concrete was removed and the face repaired and shotcreted from the top of the dam to about elevation 335 feet MSL over the entire length of the dam.

c. Spillway - The spillway structure appears to conform to the contract plans except that a permanent concrete parapet has been constructed in lieu of removeable flashboards thus raising the spillway to elevation 357 feet MSL. No significant cracking or spalling was observed, nor was any misalignment observed. The downstream channel is overgrown and contains numerous trees and boulders.

d. Earth Saddle-Dike - Contract drawings indicate an earth saddle-dike approximately 1500 feet long at the west reservoir rim just north of Valhalla, New York. The location of this structure, approximately 30-35 feet high, was not evident in the field. Although the contract drawings indicate toe drains at the downstream toe of the dike they were not located in the field. Grade changes subsequent to original construction have apparently integrated this dike into the landscape so that its location is not discernible in the field. However, no misalignment or visual sloughing or seepage was evident in the general area of the dike.

e. Upper Chamber - Upper (elevation 320) and lower (elevation 250) sluice gate operators appeared in good working order and well maintained. Both gates are electric motor driven and can be manually operated in the event of power failure.

f. Lower Chamber - Gate valves controlling the flow to the Bronx conduct and blow-off are of the manually operated type and from all outward appearances look operable. The blow-off has never been used.

g. Delaware and Catskill Aqueduct By Pass, and Kensico Outlet and Chlorination Buildings - All gates and equipment appeared well maintained and in good working order. Gates are electrically operated. In the event of power failure a portable generator is available for emergency power.

3.2 EVALUATION:

Visual observations revealed that the dam and appurtenant structures are structurally sound and maintained in excellent condition by New York City personnel.

SECTION 4: OPERATIONAL PROCEDURES

4.1 PROCEDURES:

Impoundment elevations are read daily by the staff of the Bureau of Water Supply. During periods of concern the elevations are read hourly. The pool elevation is maintained at approximately six inches below the spillway crest by regulating the inflow from the Catskill and Delaware Aqueducts, either feeding wholly or partially into the reservoir or by-passing. The inflow from the Delaware Aqueduct is controlled at the Kensico Reservoir, but can only be shut down at Shaft 10 at the West Branch of Croton Reservoir in Putnam County, New York. The Catskill Aqueduct, while controlled at Kensico, can only be shut down at Ashokan Reservoir. The aqueduct out-take from the reservoir is a function of the daily requirements of Hill View Reservoir, the next link in New York City's supply system. The 48 inch diameter "Bronx Line" is in constant use supplying several Westchester holding tanks and consumers with their water needs. Since the watershed area of Kensico Reservoir is relatively small compared to the aqueduct flows, the impoundment can be effectively controlled in this manner.

4.2 MAINTENANCE OF THE DAM:

The dam and appurtenant works are maintained in excellent operational condition.

4.3 MAINTENANCE OF OPERATING FACILITIES:

The operating facilities are maintained in excellent operating condition by New York City personnel. They are staffed on an around the clock basis.

4.4 DESCRIPTION OF WARNING SYSTEM:

No warning system is present.

4.5 EVALUATION:

The dam and appurtenant works are maintained in excellent condition. Maximum draw down capability is approximately two feet per 24 hour period. This information was furnished verbally. The reservoir has not spilled water since 1921. This is indicative of the fine control of reservoir stage possible by the operating procedure utilized.

SECTION 5: HYDROLOGY/HYDRAULIC

5.1 HYDROLOGIC EVALUATION OF FEATURES:

a. Design Data - The massive wall of Kensico Dam spans the valley of the Bronx River to form Kensico Reservoir. The drainage area contributing to the reservoir is 12.8 square miles, including 3.5 square miles of reservoir water surface. The volume of the impounded water is more a function of the inflow from the Catskill and Delaware Aqueducts which feed the reservoir, than a function of the natural watershed contributing to the reservoir. The Kensico Reservoir fulfils its primary purpose as an intermediate storage facility for New York City's Water Supply System. Secondarily, the Kensico Dam functions as a flood detention structure. For the purpose of this investigation, the dam and spillway were analyzed with respect to their flood control potential. This potential was assessed through the development of the Probable Maximum Flood (PMF) for the watershed and the subsequent routing of the PMF through the reservoir system. The PMF is that hypothetical flow induced by the most critical combination of precipitation, minimum infiltration losses, and concentration of run-off at a specific location, that is considered reasonably possible for a particular drainage area.

The basis hydrologic working tool, the unit hydrograph, was defined by the Snyder Coefficients, Tp and Cp. The values of Tp=5.6 and Cp=.33 were developed through watershed modeling analysis. In light of recent guidelines for determining the Probable Maximum Precipitation (Hydrometeorological Report No. 51 - Sept. 1976), the PMP index rainfall was determined to be 24.6 inches for a 24 hour duration, 200 square mile basin. The percentages of the index rainfall applied to other duration storms were interpolated from the plot of drainage area versus percent of the 24 hour, 200 square miles depth (see Appendix "C"). The PMF inflow hydrograph was determined by applying the PMP to the unit hydrograph for the basin the peak flow was 10,200 CFS. After routing the PMF through the impounded storage, an outflow hydrograph was derived. The peak flow of the outflow hydrograph was 2,740 CFS. A plot of the PMF inflow and outflow hydrographs is included in Appendix "C".

Several assumptions were made concerning the discharge-storage relationships of the Kensico Reservoir:

(1) That the initial storage of the reservoir prior to the PMF was 93,780 acre-feet (30.57 billion gallons) at spillway crest elevation of 357 feet above MSL.

(2) That only the 50 foot spillway was active in discharging PMF flows.

(3) That the Catskill and Delaware Aqueducts are not discharging water into the reservoir during the PMF.

The assumptions made were conservative in light of Kensico Reservoir's discharge-storage capabilities. Normally, the pool elevation is at least .5 feet below spillway level, thus allowing for more storage of the PMF than

assumed. The discharge capacity of the dam would be augmented by the utilization of the 10 feet diameter blow-off. This blow-off has been assumed to be passive. The significant flow from the aqueducts has been ignored because the aqueduct intake system is capable of passing flows in excess of those the aqueducts can discharge into the reservoir. In addition, the flow from the Delaware and Catskill Aqueducts can by-pass the reservoir entirely.

Based on the preceding assumptions, the routed PMF peak of 2,740 CFS results in a spillway surcharge of 6.5 feet (elevation - 363.5 feet above MSL). The top of the dam is at elevation 370 feet.

b. Experience Data - Kensico Dam has been operational for more than 60 years. During this time, it has safely and efficiently stored and discharged the flood events which have been generated in its Westchester and Fairfield Counties watershed. Daily readings of pool stage have been recorded. At times of concern, stage readings are taken on an hourly basis. Records of corresponding storages have been kept throughout the years. The greatest known impoundment (30.98 billion gallons) was recorded 1 July 1922. This corresponds to an elevation of about 357.4 feet and a spillway discharge of nearly 80 CFS. This is the only recorded storage in excess of the spillway elevation capacity of 30.57 billion gallons. There is no indication that the spillway has spilled on any other occasion throughout the dam's history. The lowest storage (14.23 billion gallons) was recorded 1 Nov 1949 following the drought period of the same year.

c. Visual Observations - At the time of the on-site inspection, the pool elevation was 356.5 feet or .5 feet below the crest of the spillway. The spillway channel exhibited a lack of use. Overgrowth along the channel walls and bottom was infringing on the capacity of the channel to discharge design flows. In a few spots along the channel, the gradient was too slight to prevent minor ponding (apparently a result of snowmelt).

d. Overtopping Potential - It has been shown that the Kensico Dam (spillway) can safely discharge the PMF with a spillway surcharge of 6.5 feet with only the spillway functioning, a routed peak flow of 7500 CFS is necessary to overtop the dam at elevation 370 feet. No historical flood has ever approached overtopping of the Kensico Dam wall. Regulation of the aqueduct inflow and outflow has proven effective in maintaining a desireable pool level, thus limiting the probability of overtopping the dam wall during large storm events.

SECTION 6: STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

a. Visual Observations - No misalignment of or seepage through the structures was observed. No structural cracking of the structures was observed.

b. Design and Construction Data - Although design data for Kensico dam is not available, engineering principles governing the design of Kensico and other similar dams of the period, built under the auspices of the Board of Water Supply of the City of New York is outlined in "DESIGN AND CONSTRUCTION OF DAMS", Wegmann, 1927. Portions applicable to Kensico Dam design and construction have been utilized in the preparation of this report and copies have been retained in the New York District file. On the assumption that the principles outlined in the above reference were applied in the design of Kensico Dam it can be assumed sound engineering principles were used and the fundamental requirements of the present state of the art have not been violated. This, together with the descriptions available of the grouting procedures and other foundation treatment are considered to have rendered the dam stable beyond any reasonable doubt. A general construction history is contained in the above reference. In addition, the "Annual Reports of the Board of Water Supply" City of New York contains a detailed construction history of Kensico Dam. Acceptable construction methods were employed throughout the project.

c. Operating Records - The level of the impoundment is carefully checked on an around the clock basis by operating personnel. The level is maintained at six inches below the spillway crest. Records indicates very little fluctuation in this level and the spillway has not overflowed since 1921.

d. Post Construction Changes - The flashboards atop the spillway were originally intended to be 18 inches in height and removeable. They have been replaced by a permanent concrete parapet two feet in height, thus creating a possible permanent pool at elevation 357 feet MSL. This change has an insignificant effect upon the structural stability.

e. Seismic Stability - The dam is located in seismic zone number one; therefore no hazard from earthquake forces should exist.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 DAM AND SPILLWAY ASSESSMENT:

a. Safety - Neither the dam or spillway exhibits any instability or distress which would render them unsafe in their present condition. The spillway is capable of safely passing the PMF. The dam has demonstrated its stability during its existence of over 60 years during which time the maximum recorded elevation of the impoundment was at 357.4 feet MSL.

b. Adequacy of Information - The information available is inadequate for a complete structural evaluation of the structure, however, design and construction history available in the "Annual Reports of the Board of Water Supply" and "Design and Construction of Dams", Wegmann, 1927, indicates that sound engineering principles were adhered to in the design and construction of Kensico Dam.

c. Urgency - There is no urgent need for additonal information.

d. Necessity for Phase II - Additional investigations are not required to evaluate the structure.

7.2 POSSIBLE REMEDIAL MEASURES:

Remedial measures are not required or necessary.

APPENDIX A
VISUAL AND ENGINEERING CHECKLISTS

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Kensico

ID # NY 1

ITEM	REMARKS
AS-BUILT DRAWINGS	Not Available - Construction Plans are Available
REGIONAL VICINITY MAP	✓
CONSTRUCTION HISTORY	✓
TYPICAL SECTIONS OF DAM	✓
OUTLETS - PLAN	
- DETAILS	
-CONSTRAINTS -DISCHARGE RATINGS	
RAINFALL/RESERVOIR RECORDS	

ITEM	REMARKS
DESIGN REPORTS	Not Available
GEOLOGY REPORTS	Not Available
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	NOT AVAILABLE
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	NOT AVAILABLE
POST-CONSTRUCTION SURVEYS OF DAM	NOT AVAILABLE NOT PERFORMED
BORROW SOURCES.	NOT AVAILABLE

ITEM	REMARKS
MONITORING SYSTEMS	
MODIFICATIONS	REMOVEABLE FLASHBOARDS HAVE BEEN REPLACED BY A PERMANENT CONCRETE PARAPET TO EL. 357 FT MSL
HIGH POOL RECORDS	
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	NONE
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	NONE
MAINTENANCE OPERATION RECORDS	PRECAST CONCRETE BLOCKS ON U/S FACE HAVE BEEN RESURFACED WITH SHOTCRETE FROM TOP OF DAM TO ABOUT ELEVATION 335' OVER THE ENTIRE LENGTH OF DAM. THE CONTROL FOR BLOW OFF CONDUIT APPARENTLY HAVE NEVER BEEN OPERATED OR PERIODICALLY TESTED

ITEM	REMARKS
SPILLWAY PLAN	✓
SECTIONS	✓
DETAILS	✓
OPERATING EQUIPMENT PLANS & DETAILS	

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 12.8 SQUARE MILES

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): EL. 356.5' STOR. - 30.5 BILL. GAL.

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): EL. 357' STOR. 30.58 BILL. GALL

ELEVATION MAXIMUM DESIGN POOL: SPILLWAY ELEVATION - 357'

ELEVATION TOP DAM: 370 FT. ABOVE MSL

SPILLWAY CREST:

a. Elevation 357 FT
b. Type CONCRETE OGEE WITH PERM. FLASHBOARDS
c. Width
d. Length WEIR LENGTH - 50 FT.
e. Location Spillover ~ 650 FT N.E. OF EAST END OF DAM
f. Number and Type of Gates

OUTLET WORKS:

a. Type 48" CONDUIT (ALSO AQUEDUCT INTAKE)
b. Location CENTER OF DAM - ELEVATION 217.5
c. Entrance inverts RECTANGULAR SLUICE GATES
d. Exit inverts
e. Emergency draindown facilities 10 FT. DIAMETER BLOW-OFF

HYDROMETEOROLOGICAL GAGES:

a. Type ELEVATION GAGES
b. Location UPPER AND LOWER GATE CHAMBERS
c. Records DAILY RECORDS AVAILABLE

MAXIMUM NON-DAMAGING DISCHARGE: ~~[illegible]~~ NOT AVAILABLE

Check List
Visual Inspection
Phase 1

Name Dam KENSICO County WESTCHESTER State NEW YORK ID # 51

Type of Dam GRAVITY (CONCRETE) Hazard Category I

Date(s) Inspection 12 Jan 78 Weather FAIR Temperature 40

Pool Elevation at Time of Inspection 356.5 M.S.L. Tailwater at Time of Inspection — M.S.L.

Inspection Personnel:

J. Caspe NYD
J. Dioguardi NYD
A. Barbero NYD
M. Thompson NYD
A. Lazaro NYD
L. Mandell NYD
K. Wadell Huntington Dist.
J. Weiss NYD
G. Koch, K. HARMER NYSDEC

Wadell; Caspe Recorder

A-2

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	NONE ON D/S FACE OF DAM OR AT ABUTMENTS	
STRUCTURE TO ABUTMENT/EMBANKMENT, JUNCTIONS	NO DISPLACEMENT OR SEEPAGE	
DRAINS	NO FOUNDATION DRAINS	
DRAINAGE WELLS	VERY SLIGHT SEEPAGE - NO APPARENT MISALIGNMENT	
WATER PASSAGES	NOT ACCESSIBLE	
FOUNDATION	COULD NOT BE OBSERVED	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	NONE OBSERVED	
STRUCTURAL CRACKING	NONE EXCEPT SEVERAL HORIZONTAL, LONGITUDINAL FRACTURES IN SIDE WALL OF UPPER INSPECTION GALLERY (PROBABLY MORTAR JTS OF CONC. BLOCKS)	FRACTURES WHICH ARE AT APPROX. EL 362, ARE NOT SIGNIFICANT.
VERTICAL AND HORIZONTAL ALIGNMENT	NO MISALIGNMENT IS EVIDENT	
MONOLITH JOINTS	NO APPARENT MOVEMENT	
CONSTRUCTION JOINTS	NONE OBSERVED	
STAFF GAGE OR RECORDER:	OPERATING	

A-5

EMBANKMENT *

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIO
SURFACE CRACKS	None Observed	* The Actual location of the Saddle Dike could not be ascertained in the field due to numerous grading changes. The dike appears to be well integrated into the existing landscape and its location is not discernible. Observation indicated pertains to the general area where the dike is known to exist.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None	
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	Good Alignment in General Area	
RIPRAP FAILURES	None Observed	

* EMBANKMENT

ISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
		* See remarks preceding page.
UNCTION OF EMBANKMENT ND ABUTMENT, SPILLWAY ND DAM	No misalignment evident	*
NY NOTICEABLE SEEPAGE	None	*
TAFF GAGE AND RECORDER	Not Applicable	*
RAINS	None observed	*

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	SOME MINOR CRACKING AND SPALLING ON D/S FACE	CRACKING AND SPALLING NOT SIGNIFICANT
APPROACH CHANNEL	NOT APPLICABLE	
DISCHARGE CHANNEL	Overgrown since spillway has not spilled recently.	
BRIDGE AND PIERS	No CRACKS OR MISALIGNMENT OBSERVED	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL		
APPROACH CHANNEL		
DISCHARGE CHANNEL		
BRIDGE AND PIERS		
GATES AND OPERATION EQUIPMENT		

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATI
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	NOT OBSERVED	
INTAKE STRUCTURE	NOT OBSERVED	
OUTLET STRUCTURE	NOT OBSERVED	
OUTLET CHANNEL	NOT OBSERVED	
~~EMERGENCY GATE~~ BLOW OFF	IS NOT A/O NEVER HAS BEEN OPERATED	DISCHARGE IS SMALL COMPARED TO DISCHARGE THROUGH AQUEDUCT

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDA
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	NOT OBSERVED	
SLOPES	NOT OBSERVED	
APPROXIMATE NO. OF HOMES AND POPULATION	NOT OBSERVED	

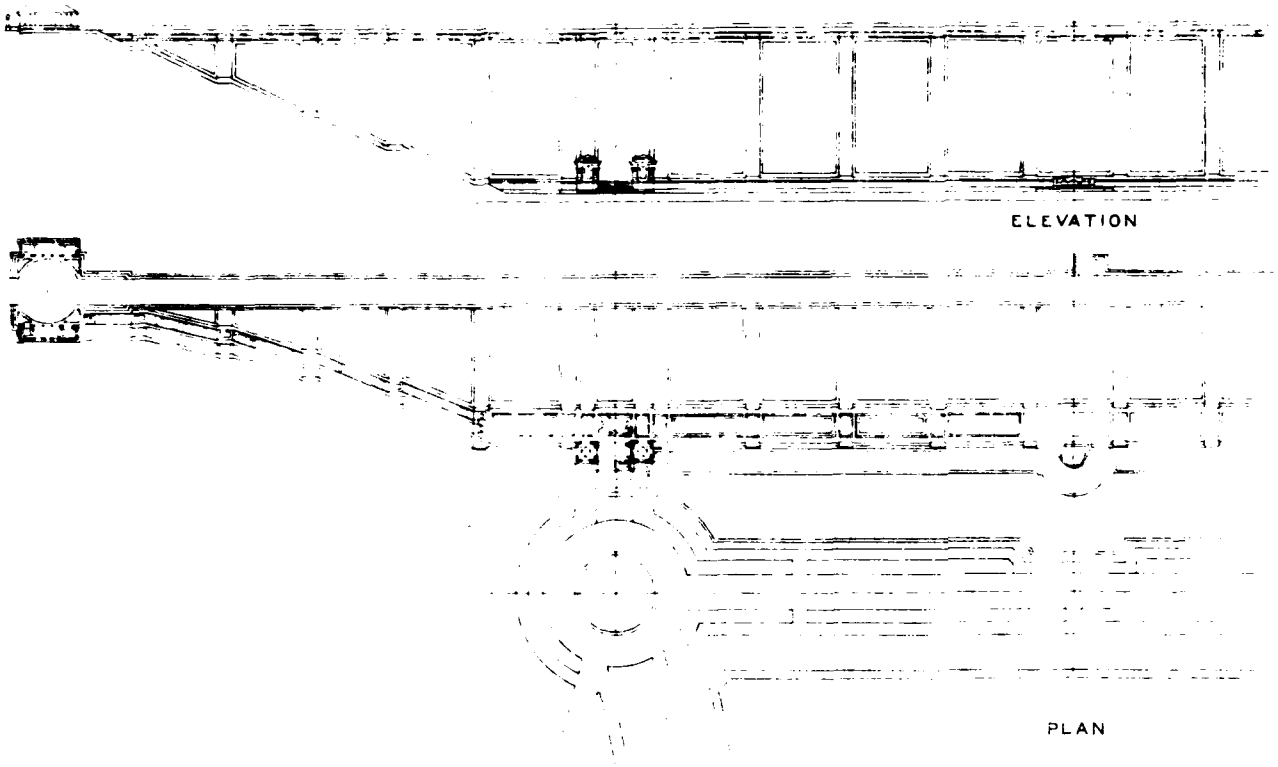
INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATION
MONUMENTATION/SURVEYS	Not Observed	
OBSERVATION WELLS	—	
WEIRS	—	
PIEZOMETERS	—	
OTHER		

RESERVOIR

ISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
LOPES	NOT OBSERVED	
EDIMENTATION	NOT OBSERVED	

APPENDIX B
PERTINENT CONTRACT PLANS



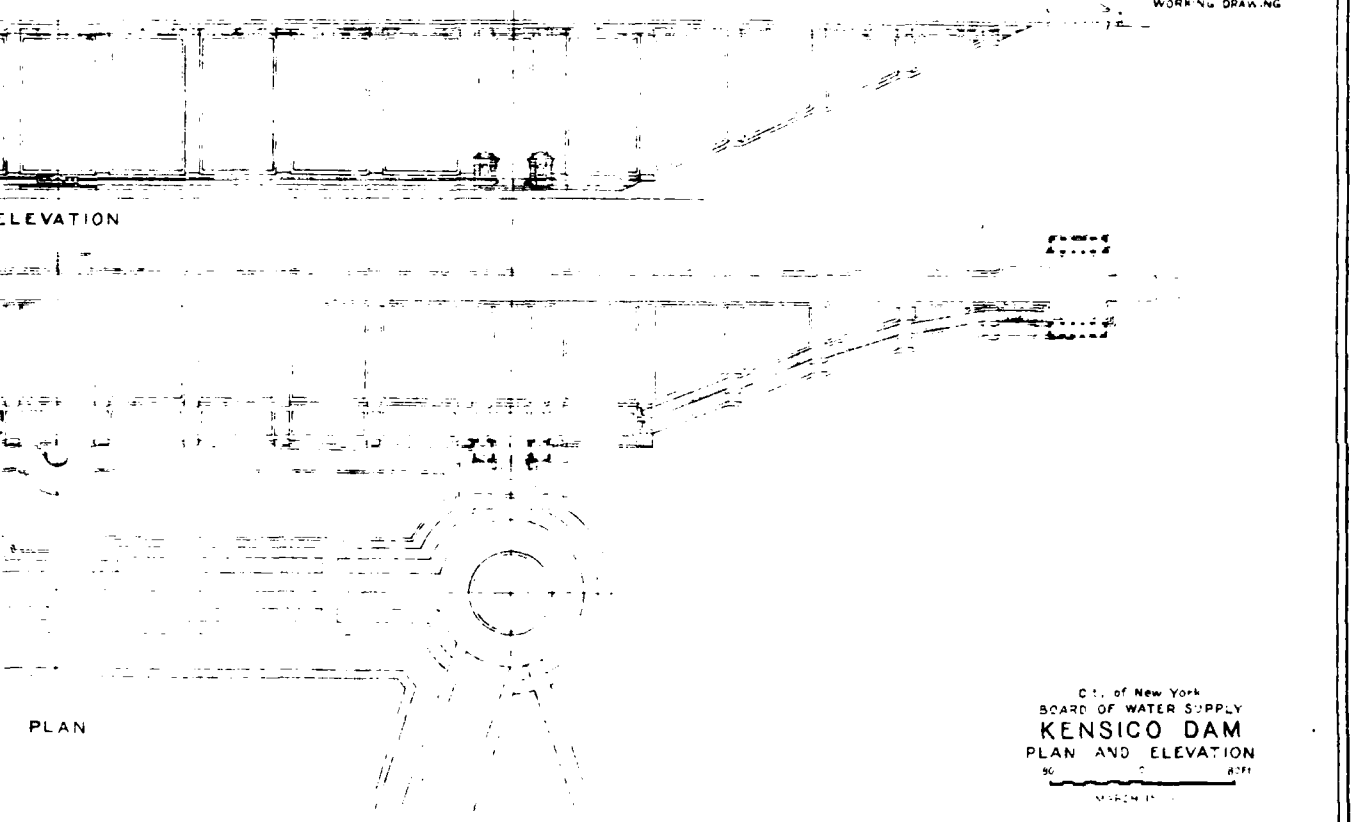
ELEVATION

PLAN

Drawn FWS 3/27/73
Traced 3/29/73
Checked

Architect

CONTRACT 9 SHEET 1A
WORKING DRAWING



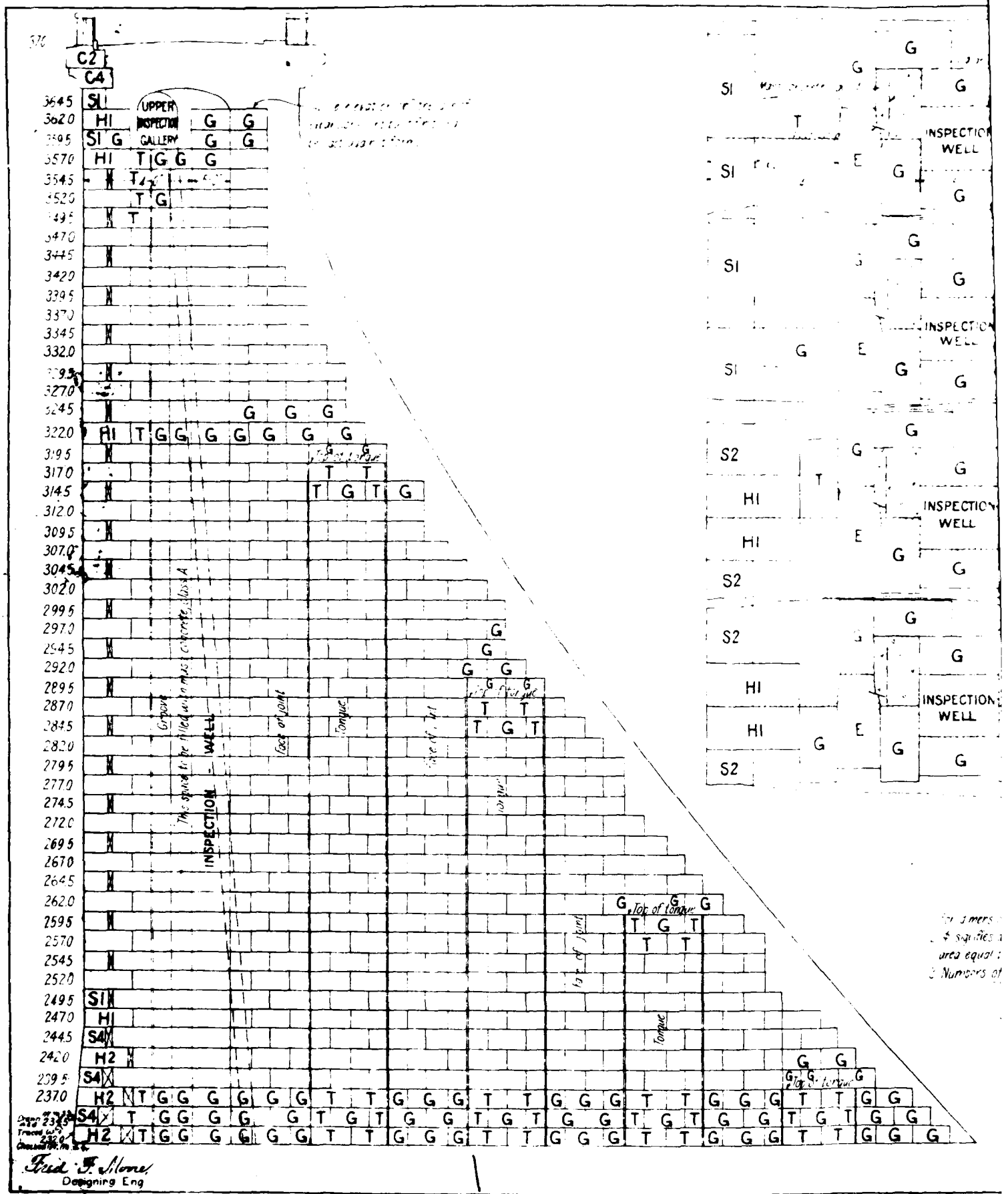
City of New York
BOARD OF WATER SUPPLY
KENSICO DAM
PLAN AND ELEVATION

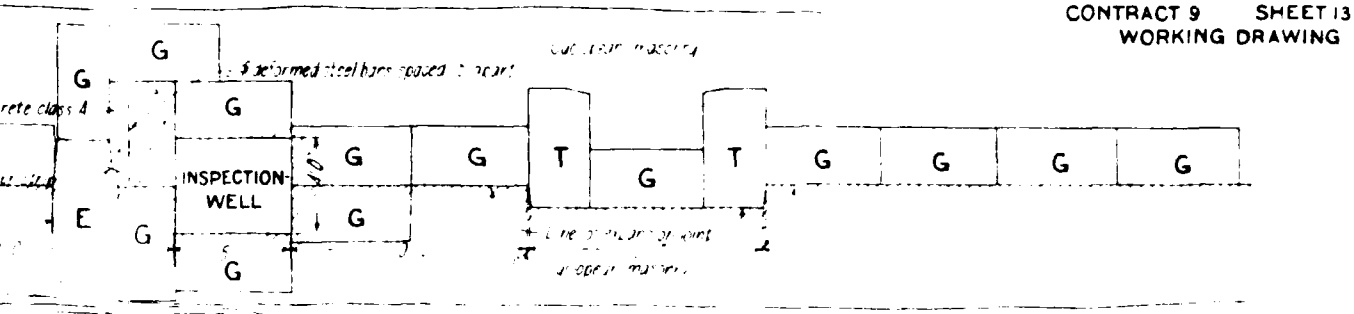
Acc 13644

2

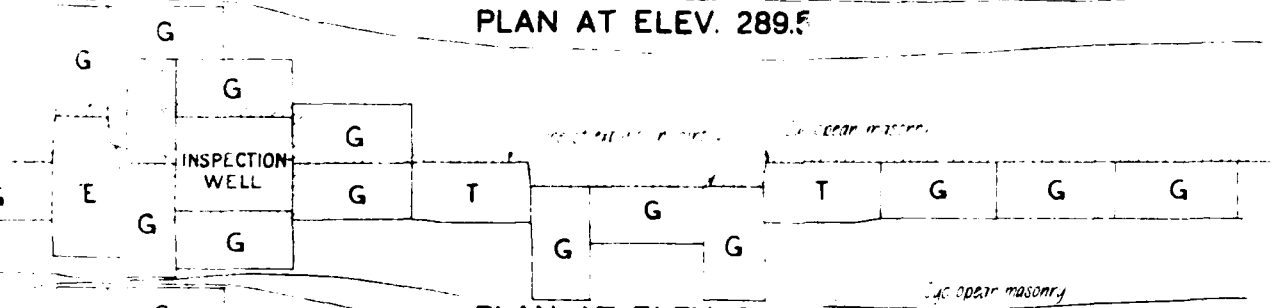
B 1

13644

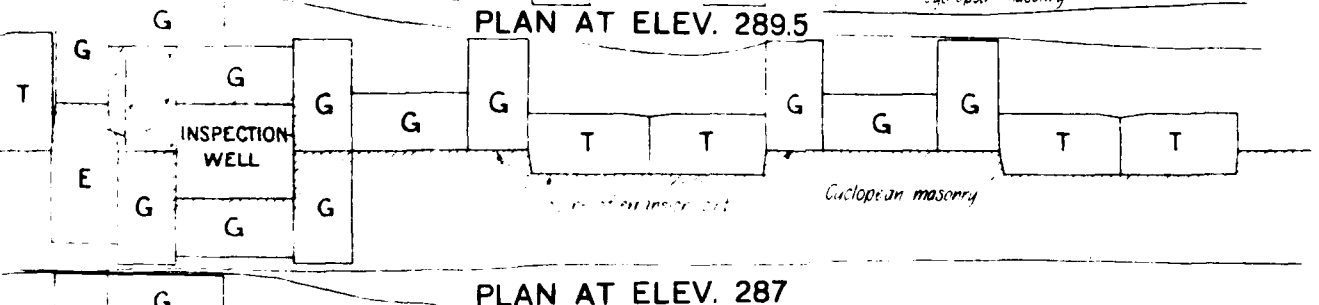

C2
C4
UPPER INSPECTION GALLERY
INSPECTION WELL
INSPECTION WELL
INSPECTION WELL
INSPECTION WELL
INSPECTION - WELL
Groove
face of joint
Tongue
Top of tongue
Fred. F. Stone
Designing Eng



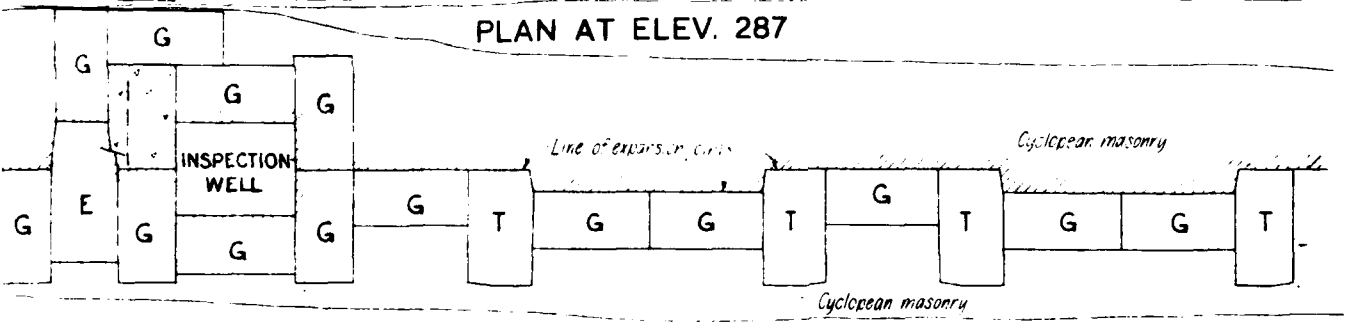
PLAN AT ELEV. 289.5



PLAN AT ELEV. 289.5



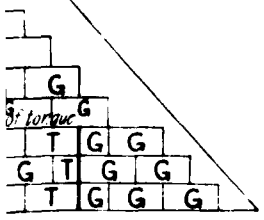
PLAN AT ELEV. 287



PLAN AT ELEV. 287

2 0 2 4 6 8 10 Ft.

For dimensions of blocks see Sheet 13D, Acc 16276
♯ signifies a deformed bar of net cross-sectional area equal to that of a round bar of the diameter given.
Numbers of courses refer to elevation of top



City of New York
BOARD OF WATER SUPPLY

KENSICO DAM

CONCRETE BLOCKS

TYPICAL ARRANGEMENT IN EXPANSION JOINTS

ELEVATION OF JOINTS ABOVE ELEV. 229.5

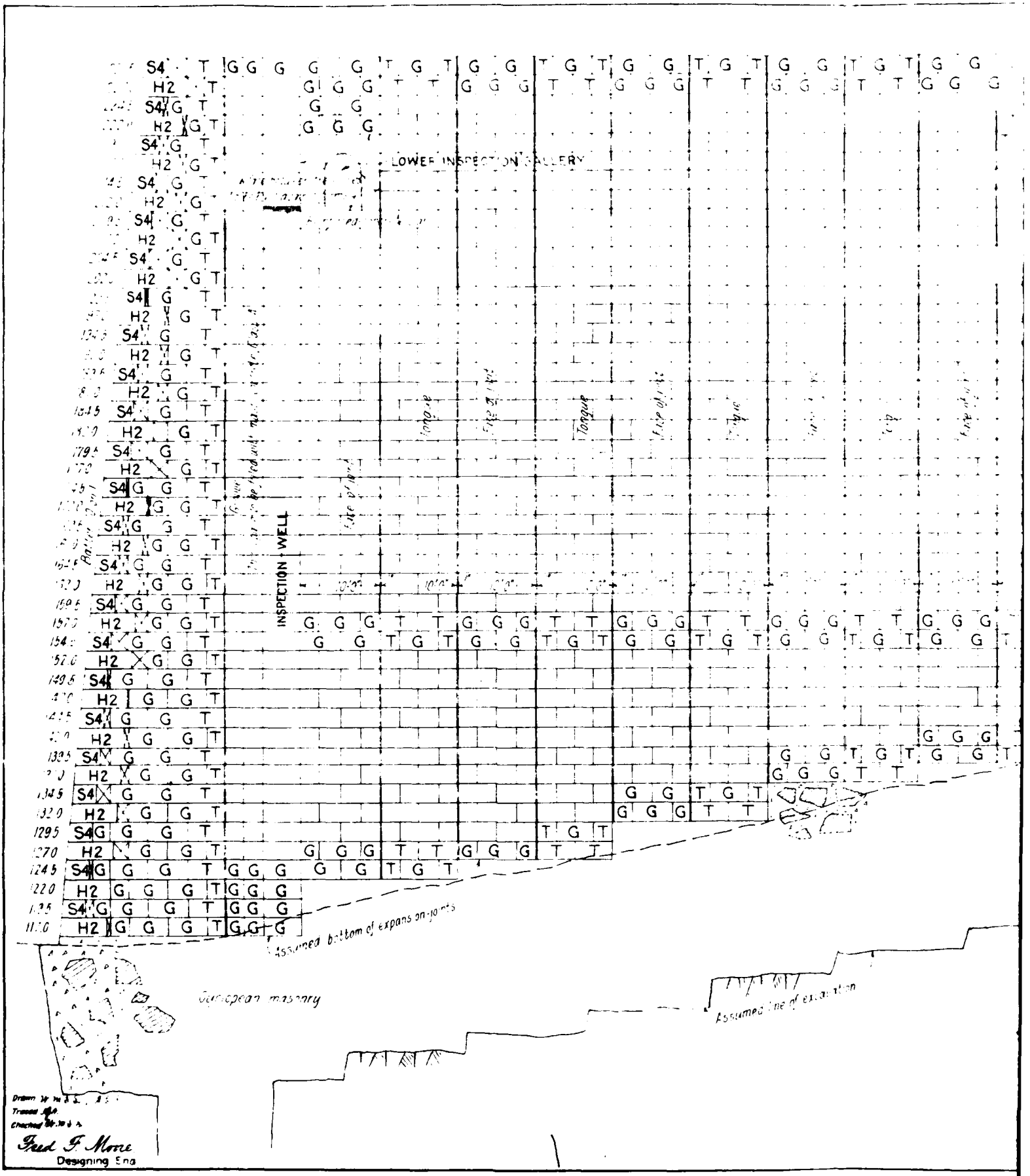
10 2 6 10 14 18 22 Ft.

JUNE 25, 1912

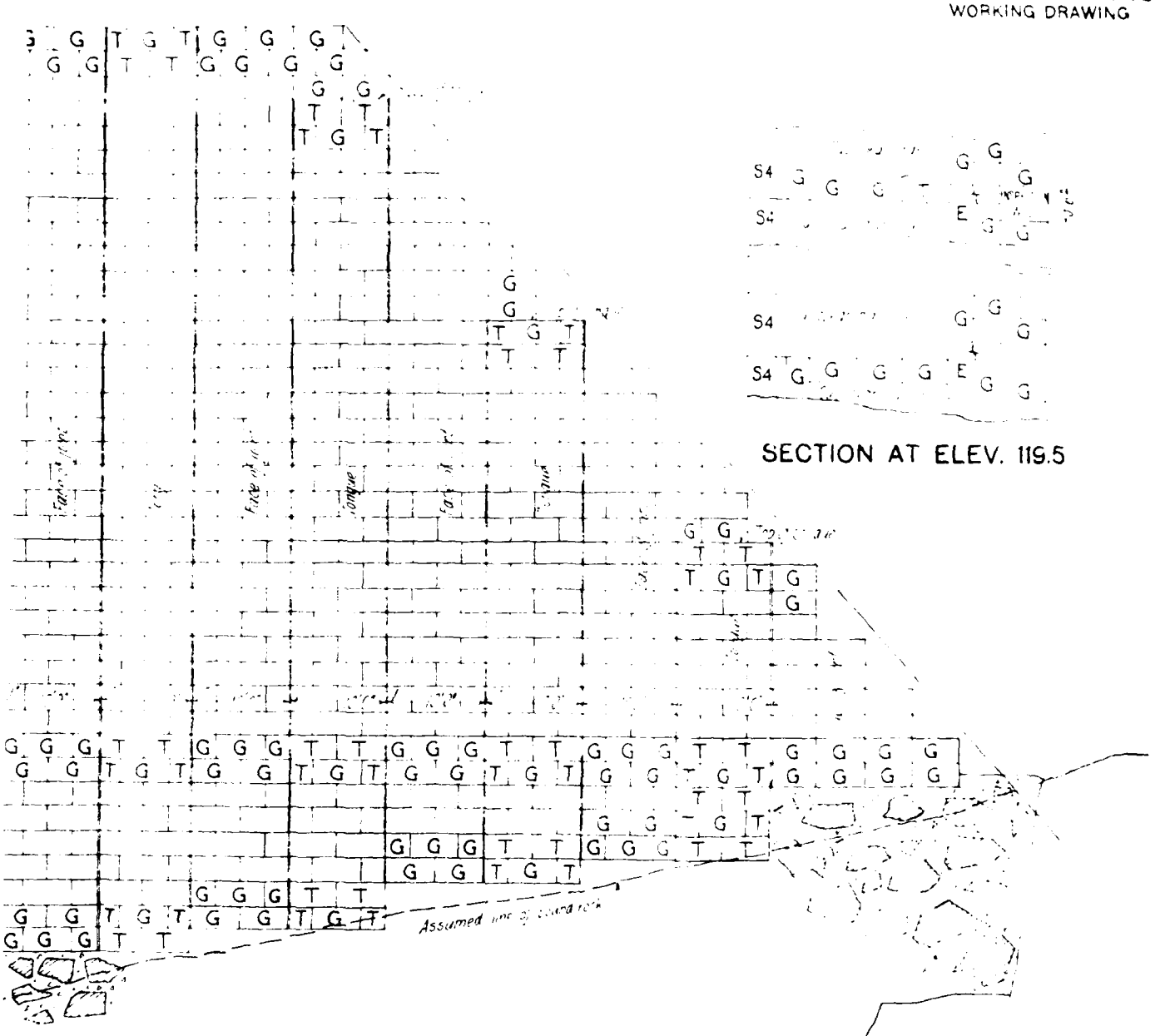
Alfred D. Flinn
Dept Eng Hdqrs

J. Waldo Smith
Chief Eng

File Cont 9-3.434 K K Acc 16278


LOWER INSPECTION GALLERY
INSPECTION WELL
Assumed bottom of expansion joints
European masonry
Assumed line of excavation
Designing Eng

CONTRACT 9 SHEET 13E
WORKING DRAWING



SECTION AT ELEV. 119.5

City of New York
BOARD OF WATER SUPPLY

KENSICO DAM

CONCRETE BLOCKS

ELEVATION OF EXPANSION-JOINTS BELOW ELEV. 229.5

0 2 6 10 14 18 22Ft.

JUNE 25, 1912

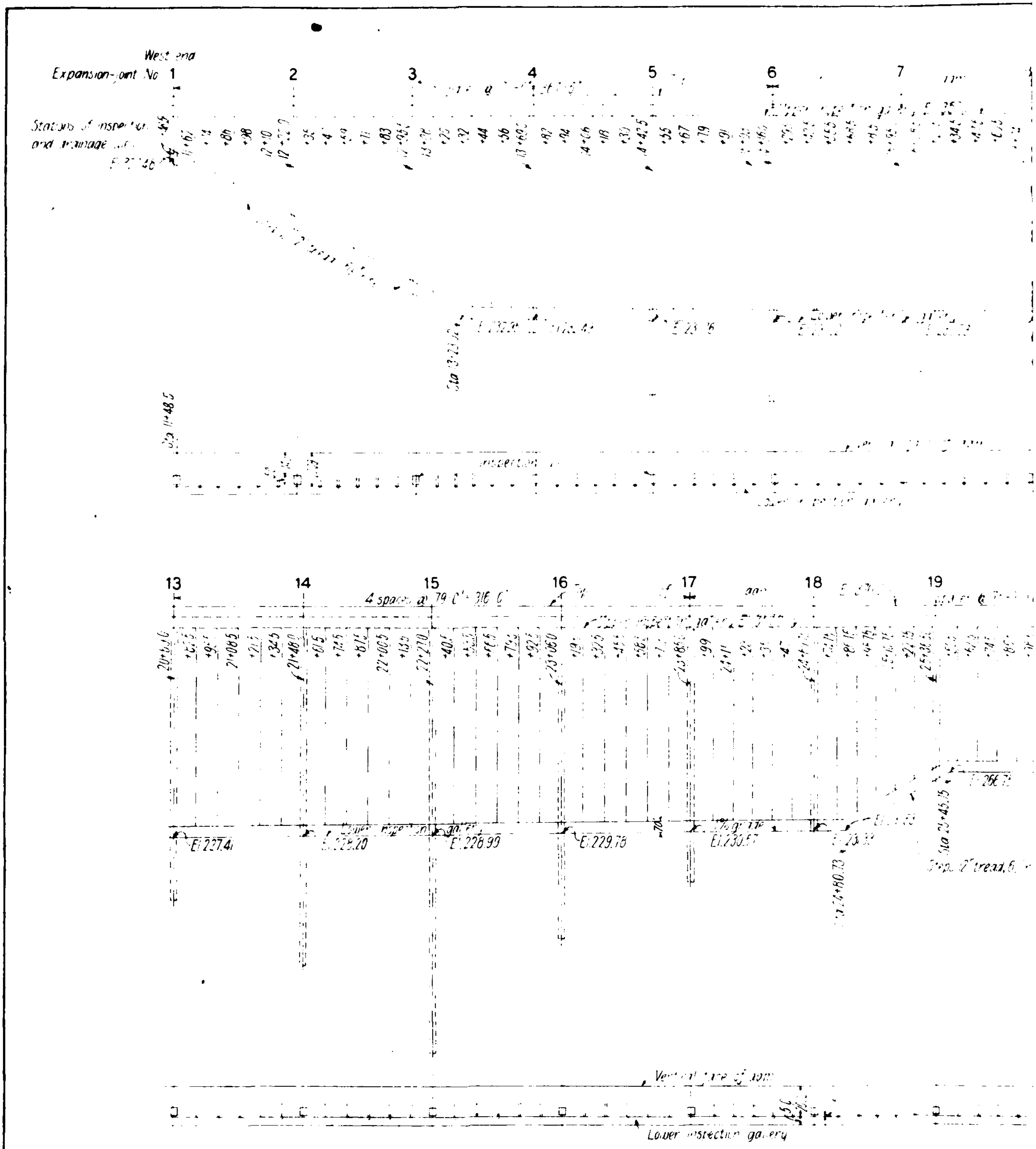
Alfred D. Flinn, Dept Eng Hdqrs

J. Waldo Smith, Chief Eng

File Cont 9-3 134 K K Acc 16277

D

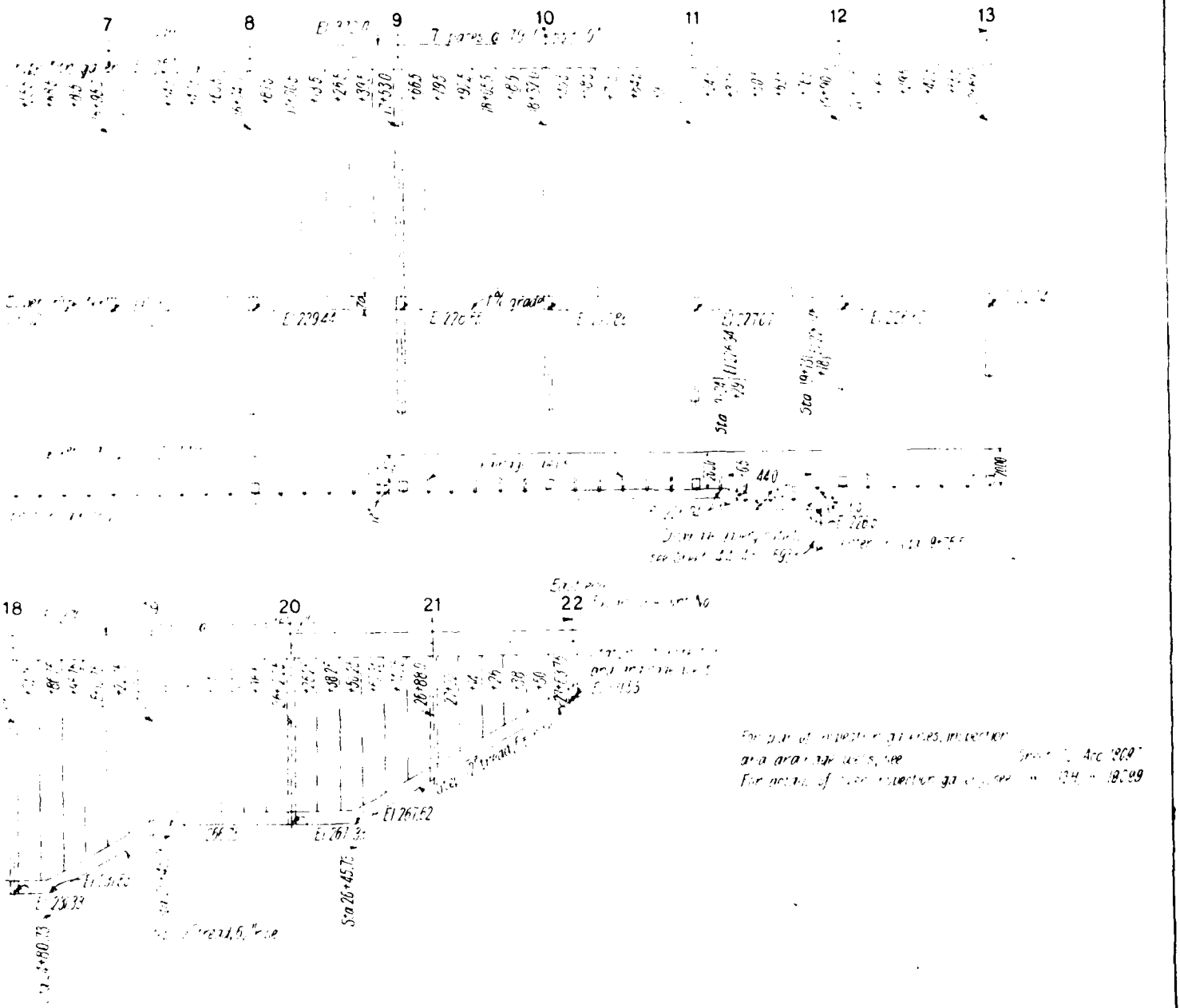
1-3



Drawn S.S.S.
Traced
Checked
Fred. F. Moore
Designing Eng

Ref.-Acc. 17597, 18039

CONTRACT 9 SHEET 13G
WORKING DRAWING



City of New York
BOARD OF WATER SUPPLY
KENSICO DAM
DRAINAGE WELLS AND LOWER INSPECTION GALLERY

40 0 40 80Ft

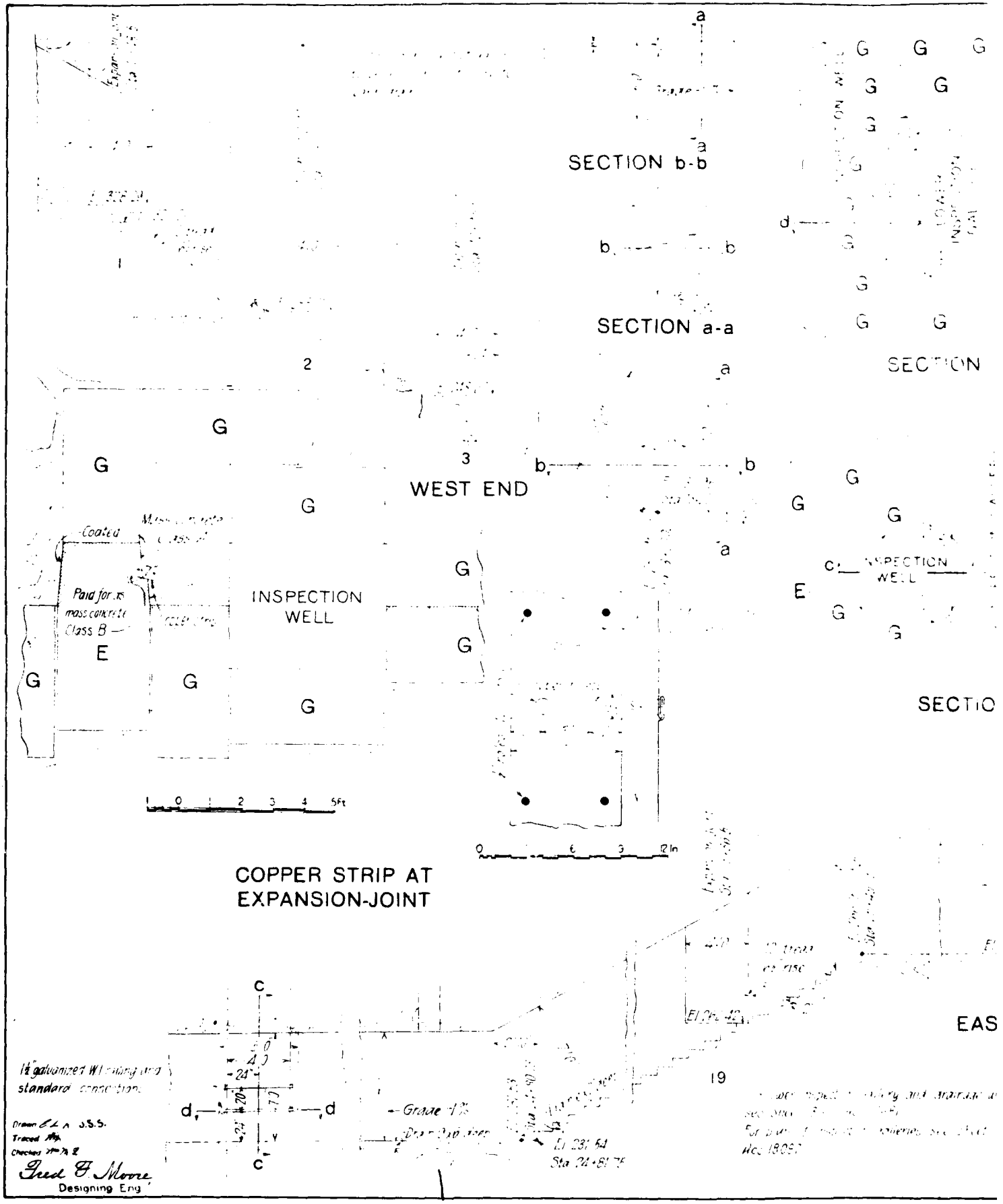
MAY 27, 1913

Alfred D. Flinn
Dep. Eng Hdqrs and Actng Chief Eng

2

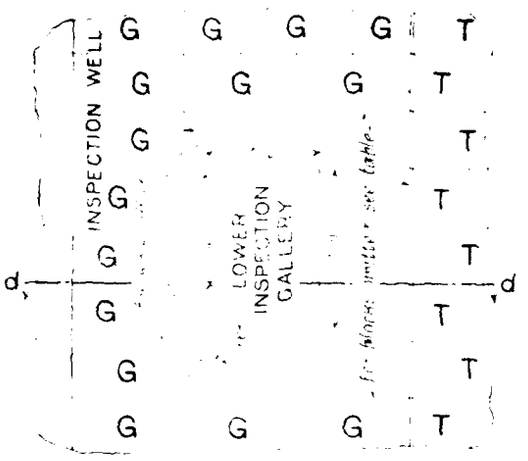
File Cont 9-3.435KK Acc 17681

B;4

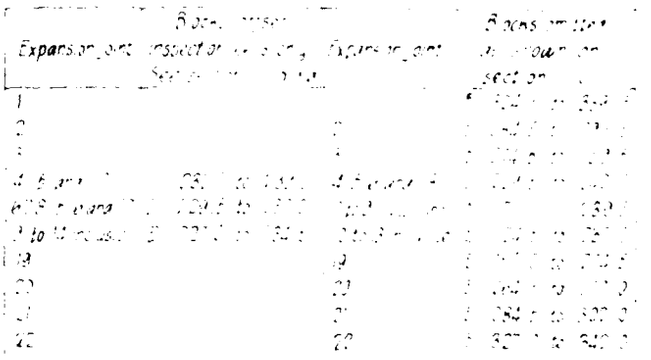


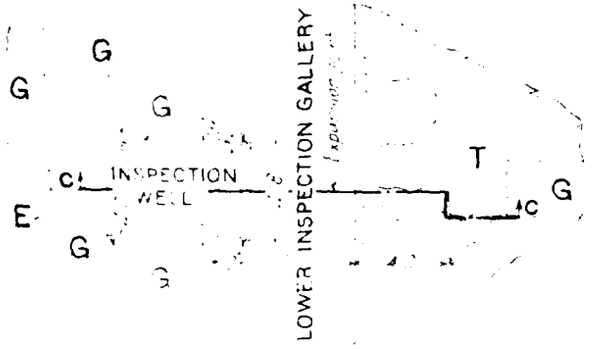
Ref - Acc 17392, 18047

CONTRACT 9 SHEET 13H
WORKING DRAWING

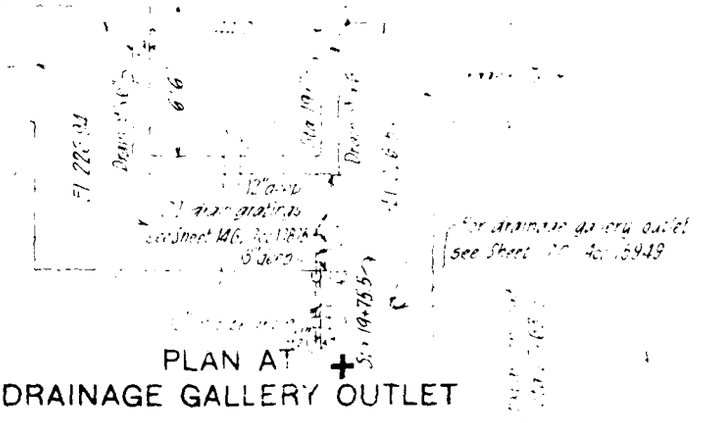


SECTION c-c

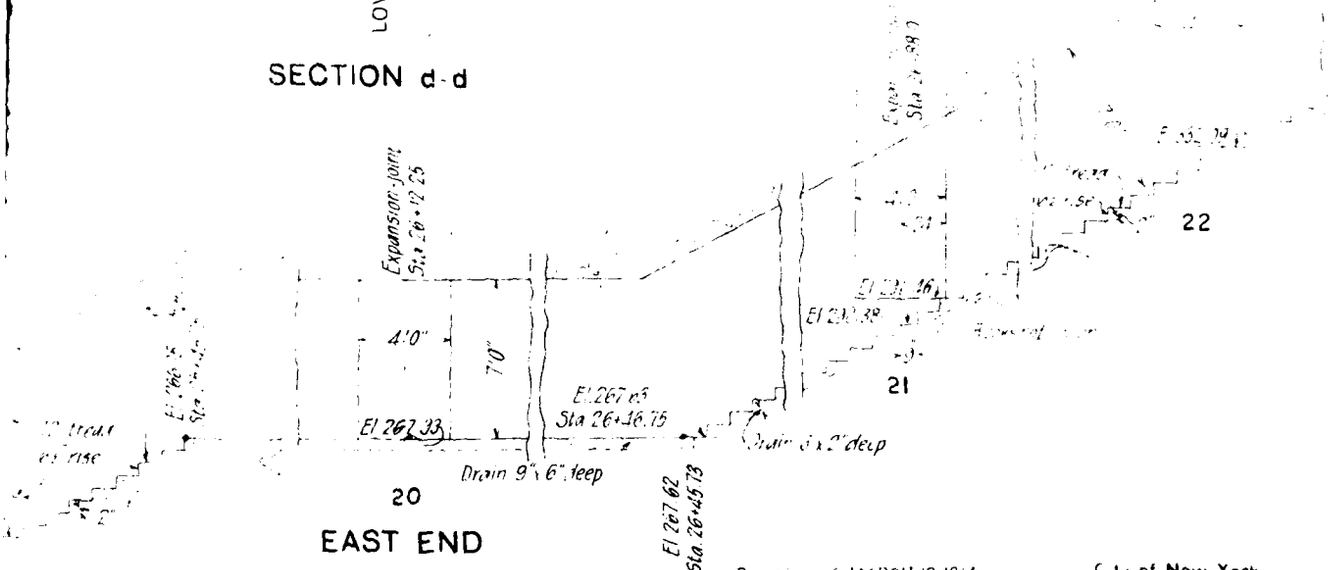




SECTION d-d



PLAN AT + DRAINAGE GALLERY OUTLET



EAST END

Revision of MARCH 13, 1914 shown thus +

City of New York
BOARD OF WATER SUPPLY
KENSICO DAM
DETAILS OF LOWER INSPECTION GALLERY

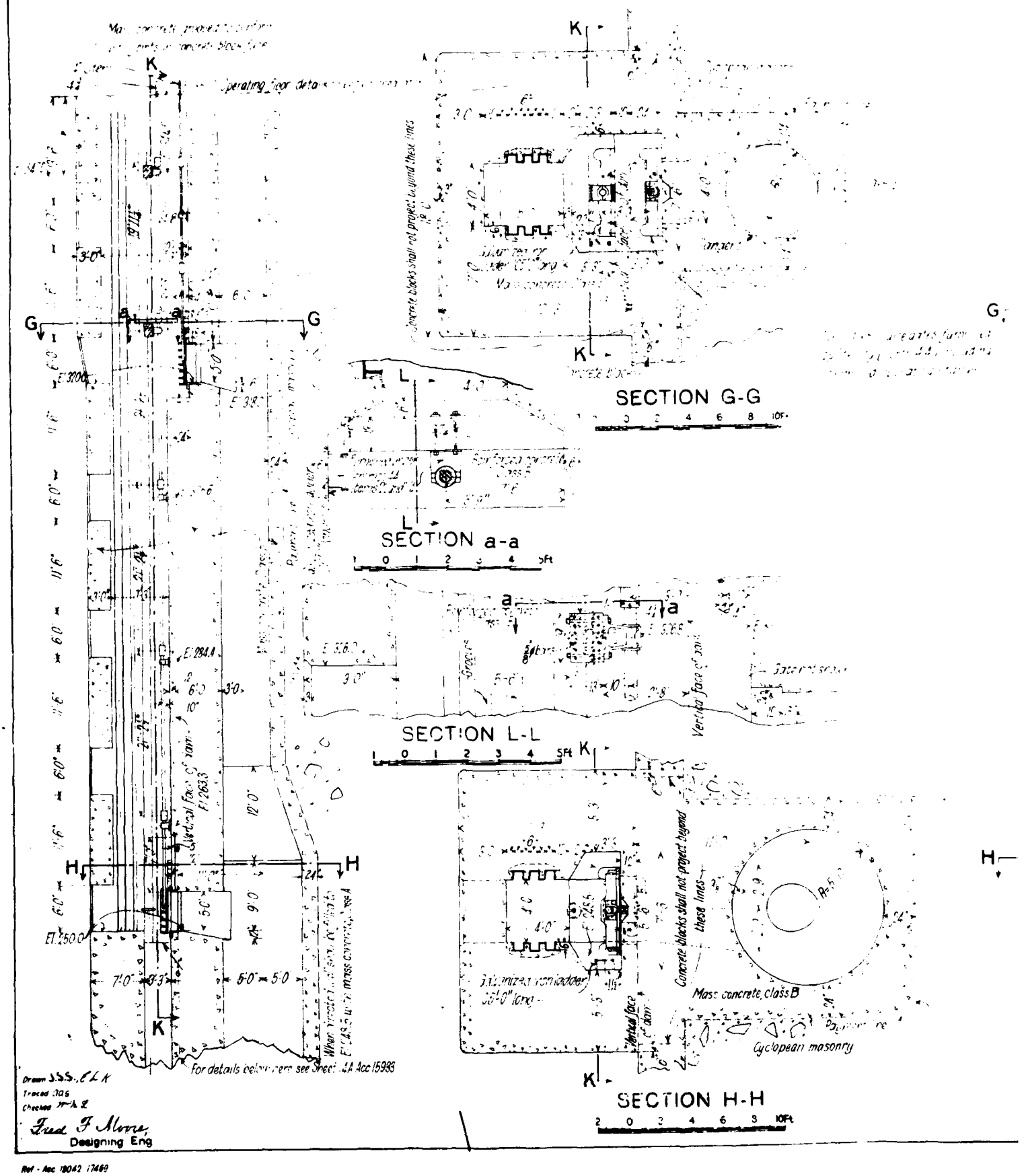
2 0 2 4 6 8 10Ft

MAY 28, 1913

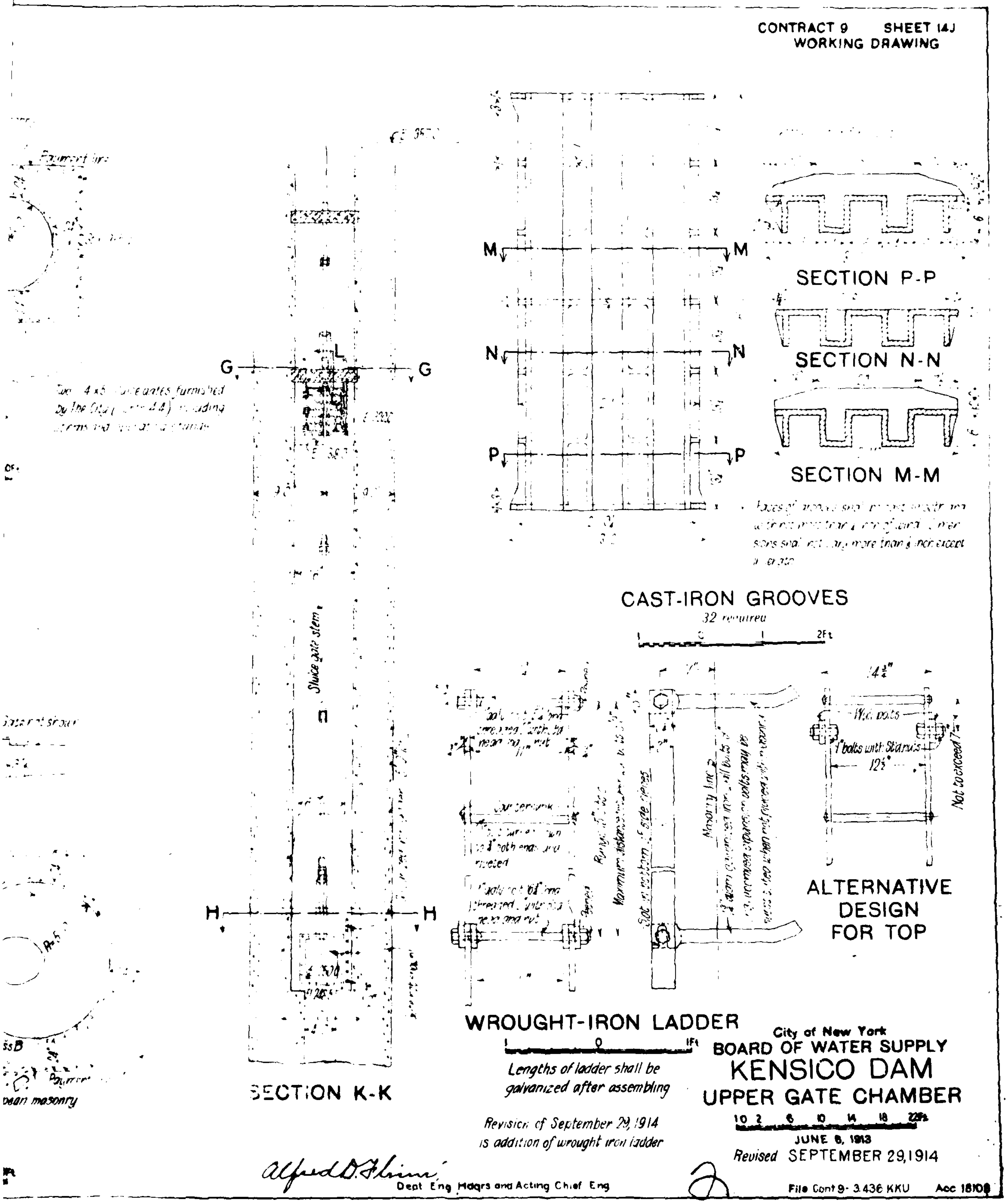
Alfred D. Flinn
Dept. Eng. Hdqrs. and Acting Chief Engr.

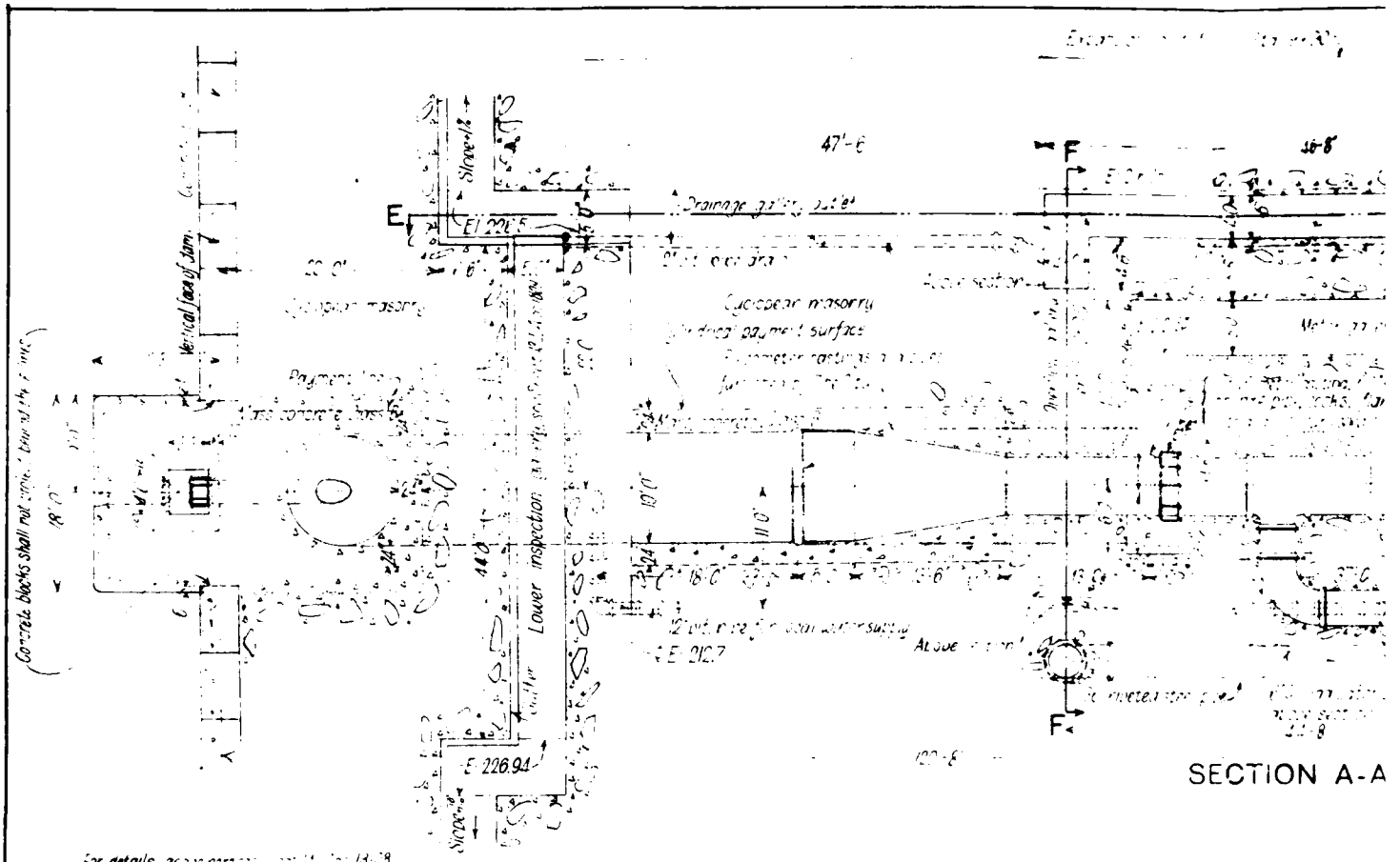
File Cont 9-3.45 KK Acc 18099

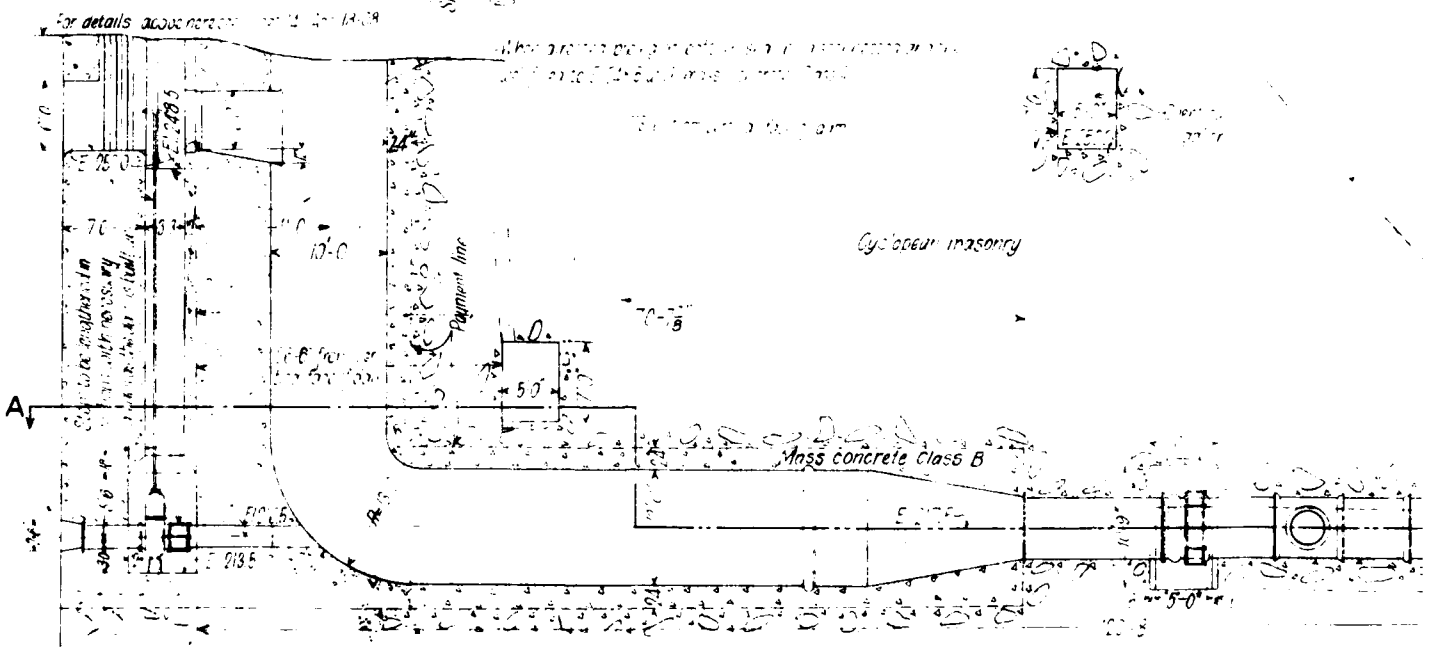
13-5



Ref - Acc 18042 17469


CONTRACT 9 SHEET 14J
WORKING DRAWING
SECTION P-P
SECTION N-N
SECTION M-M
CAST-IRON GROOVES
32 required
Sluice gate stem
ALTERNATIVE
DESIGN
FOR TOP
Not to exceed 7"
SECTION K-K
WROUGHT-IRON LADDER
Lengths of ladder shall be
galvanized after assembling
Revision of September 29, 1914
is addition of wrought iron ladder
City of New York
BOARD OF WATER SUPPLY
KENSICO DAM
UPPER GATE CHAMBER
JUNE 6, 1913
Revised SEPTEMBER 29, 1914
Dept Eng Hdqrs and Acting Chief Eng
File Cont 9 - 3.436 KKU
Acc 18108
B-4

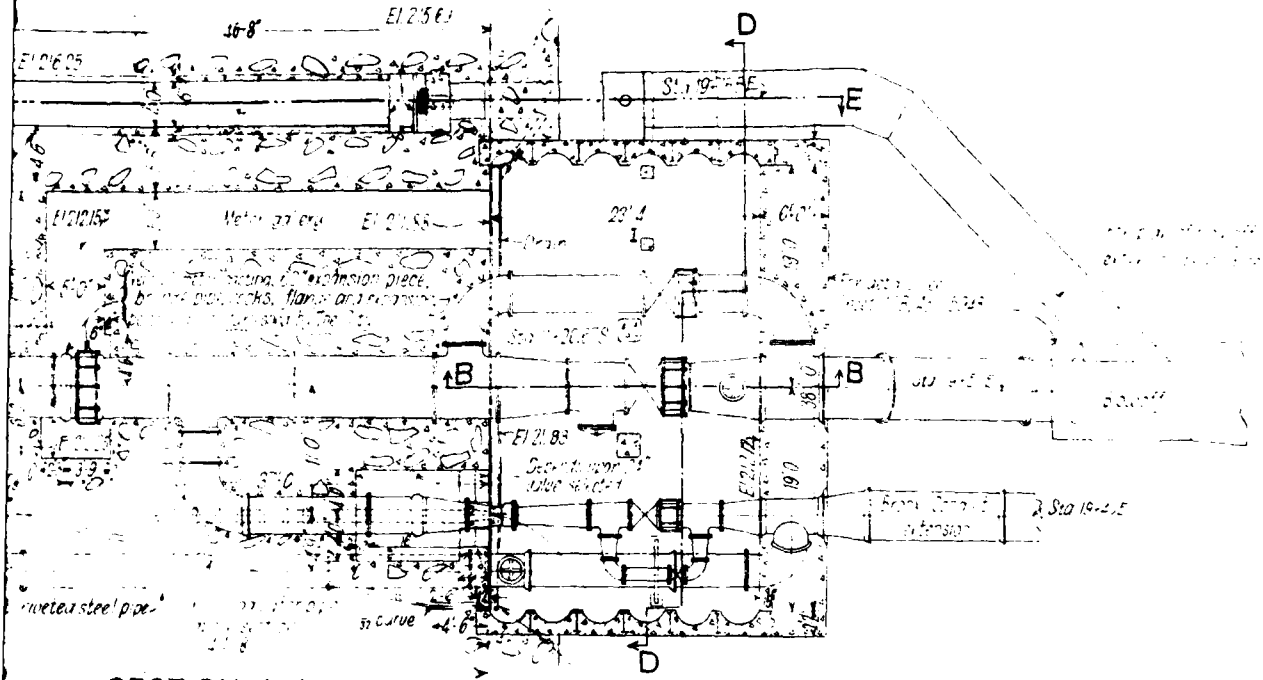




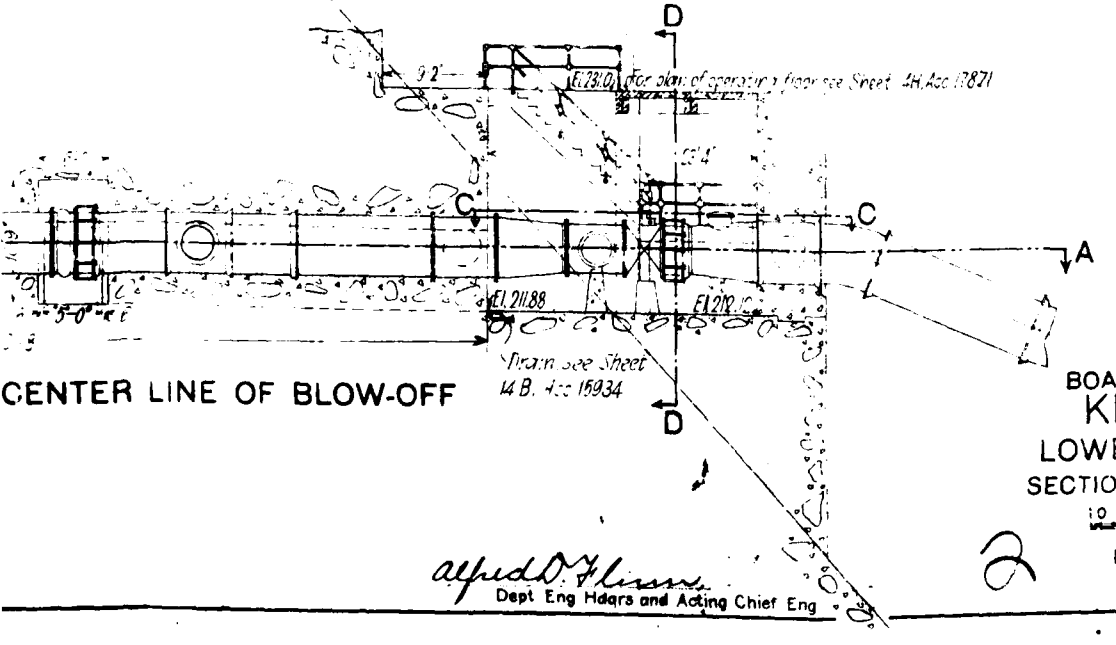
Drawn JSS
Traced D.D.B
Checked
Fred F. Moore
Designing Eng

Ref. Acc 17878

CONTRACT 9 SHEET 14A
WORKING DRAWING



For Section C-C see Sheet 14B Acc 15934
For Section B-B see Sheet 14C Acc 15935
For Section D-D see Sheet 14D Acc 15936
For Sections E-E & F-F see Sheet 17D Acc 15943



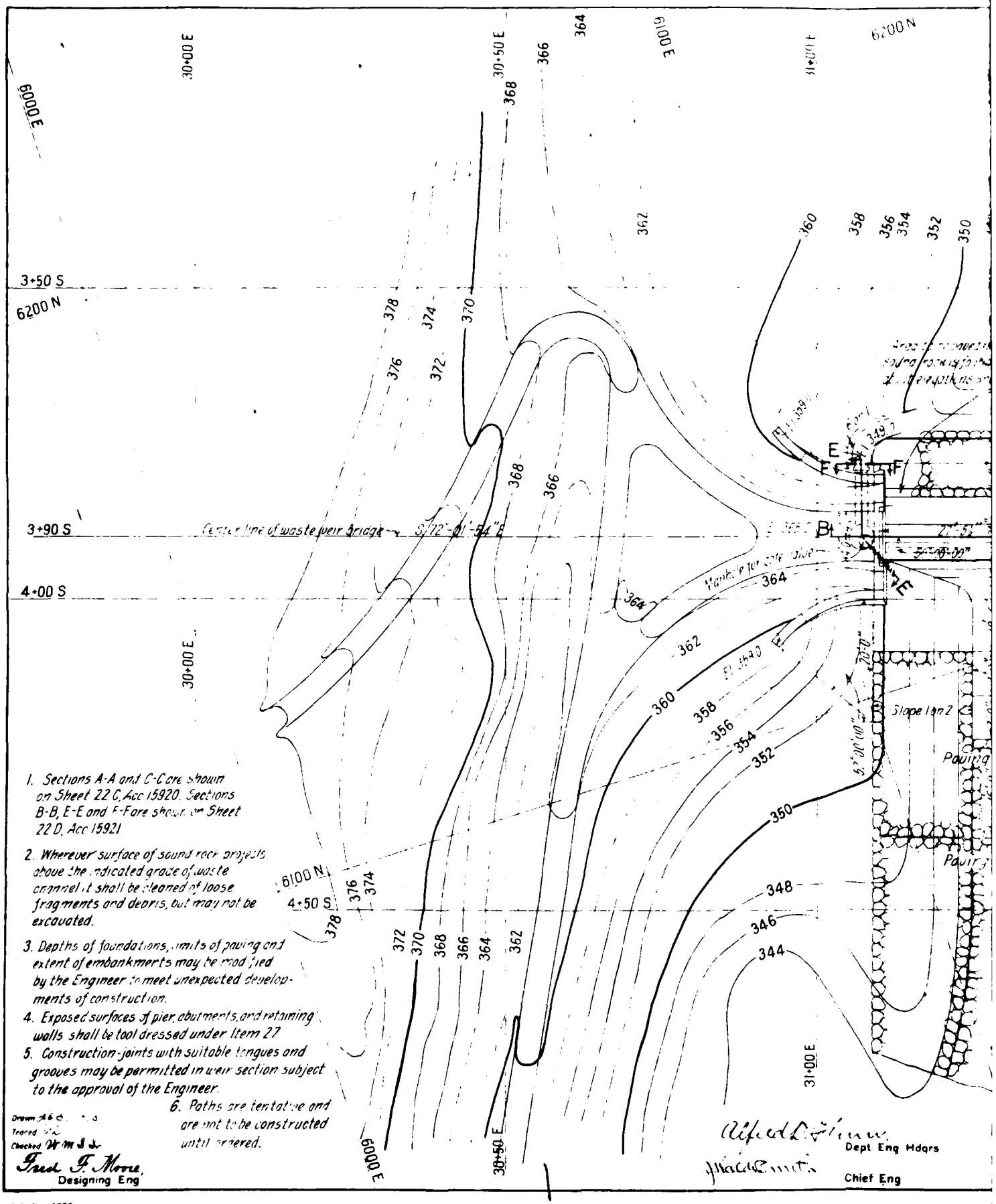
City of New York
BOARD OF WATER SUPPLY
KENSICO DAM
LOWER GATE CHAMBER
SECTIONS THROUGH BLOW-OFF

0 2 6 10 14 18 22Ft.

APRIL 7, 1913
REVISED MARCH 13, 1914

File Cont 9 - 3[illegible] Acc 15933

alfred D. Flinn
Dept Eng Hdqrs and Acting Chief Eng



1. Sections A-A and C-C are shown on Sheet 22 C, Acc 15920. Sections B-B, E-E and F-F are shown on Sheet 22 D, Acc 15921
2. Wherever surface of sound rock projects above the indicated grade of waste channel it shall be cleaned of loose fragments and debris, but may not be excavated.
3. Depths of foundations, limits of paving and extent of embankments may be modified by the Engineer to meet unexpected developments of construction.
4. Exposed surfaces of pier, abutments, and retaining walls shall be tool dressed under Item 27
5. Construction-joints with suitable tongues and grooves may be permitted in weir section subject to the approval of the Engineer.
6. Paths are tentative and are not to be constructed until ordered.

Drawn A.G.C.
Traced W.A.
Checked W.M.S. Jr.

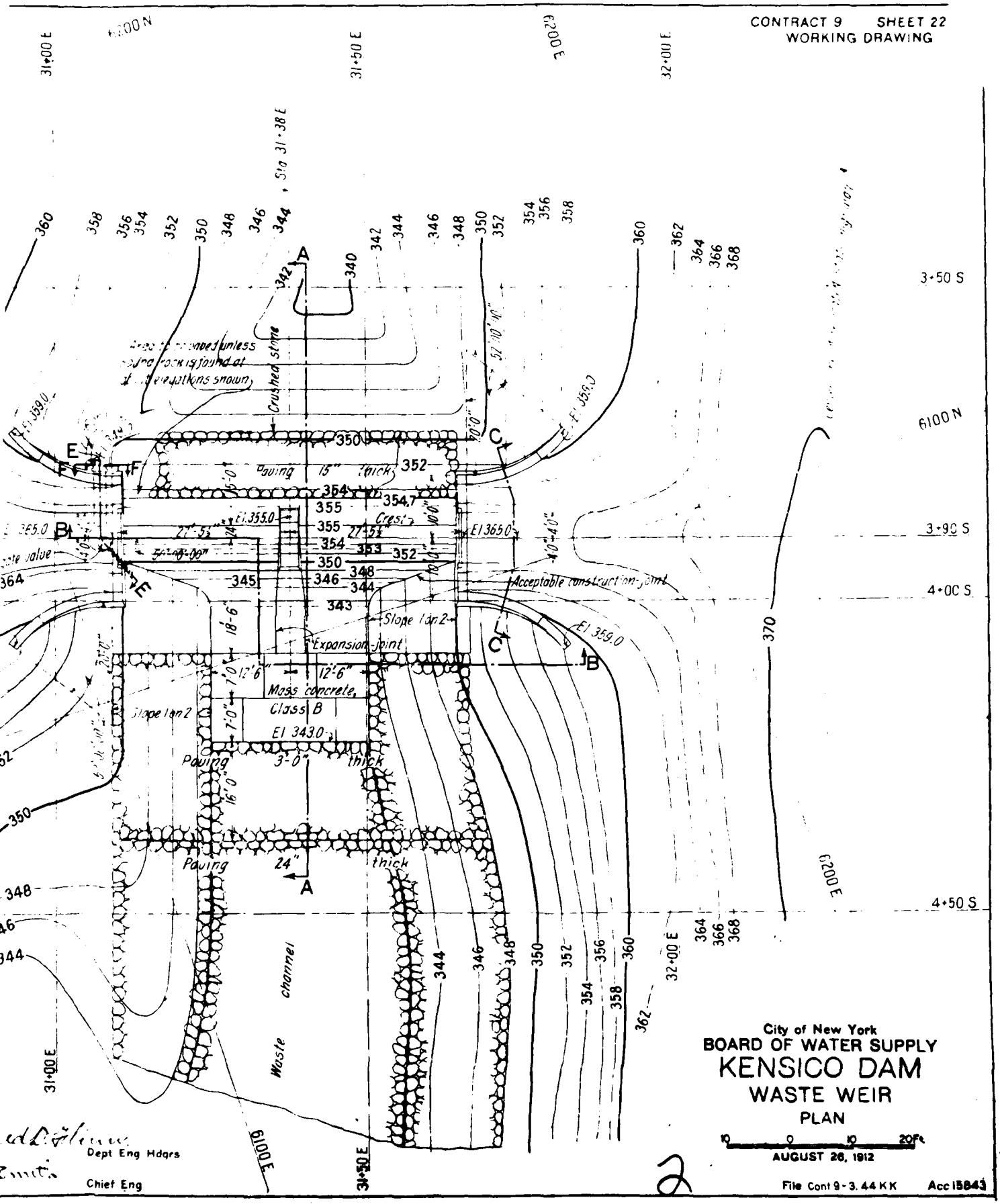
Fred F. Moore,
Designing Eng

Alfred D. Flinn
Dept Eng Hdqrs

Chief Eng

Ref - Acc 16372

CONTRACT 9 SHEET 22
WORKING DRAWING



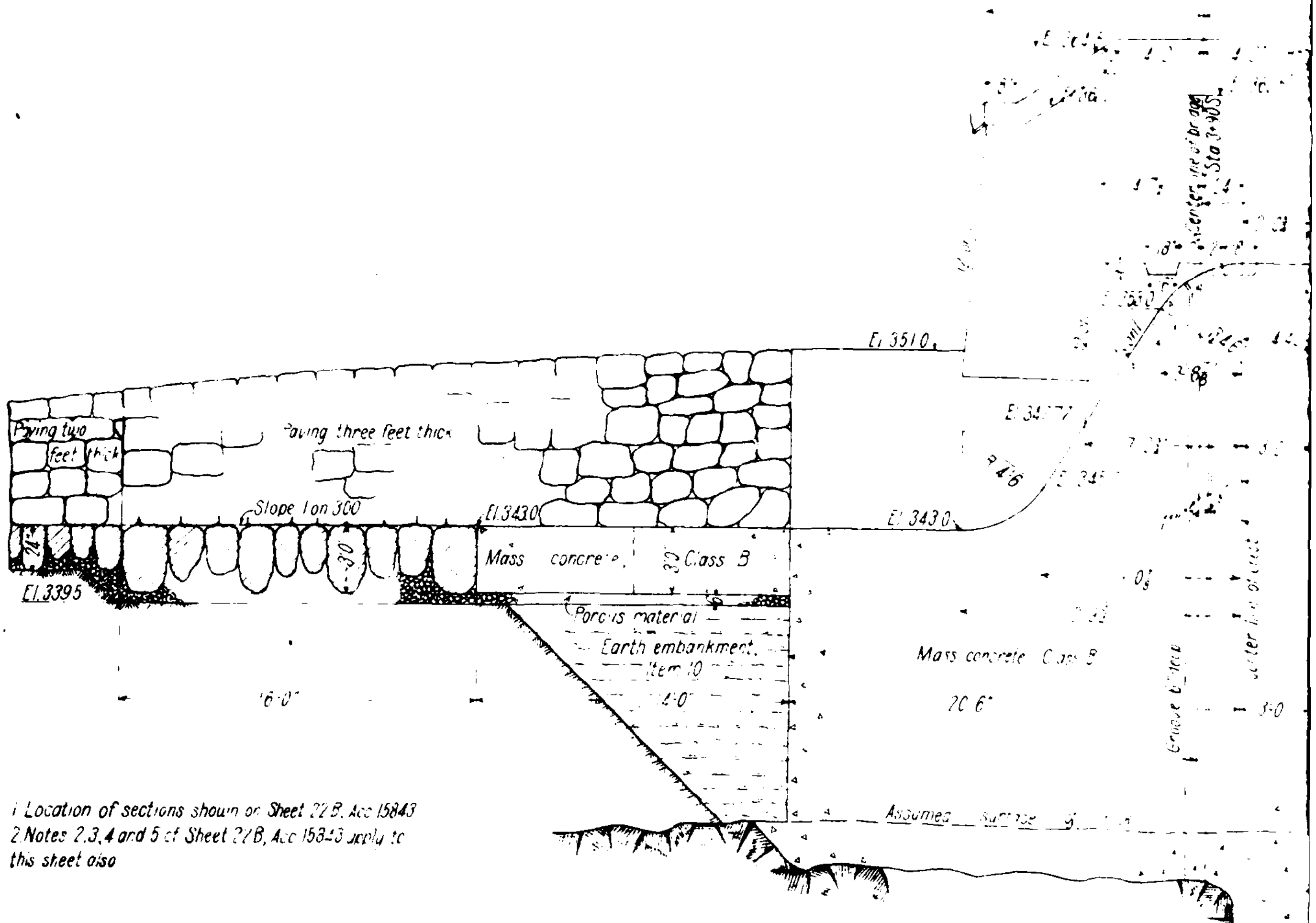
City of New York
BOARD OF WATER SUPPLY
KENSICO DAM
WASTE WEIR
PLAN

10 0 10 20Ft

AUGUST 26, 1912

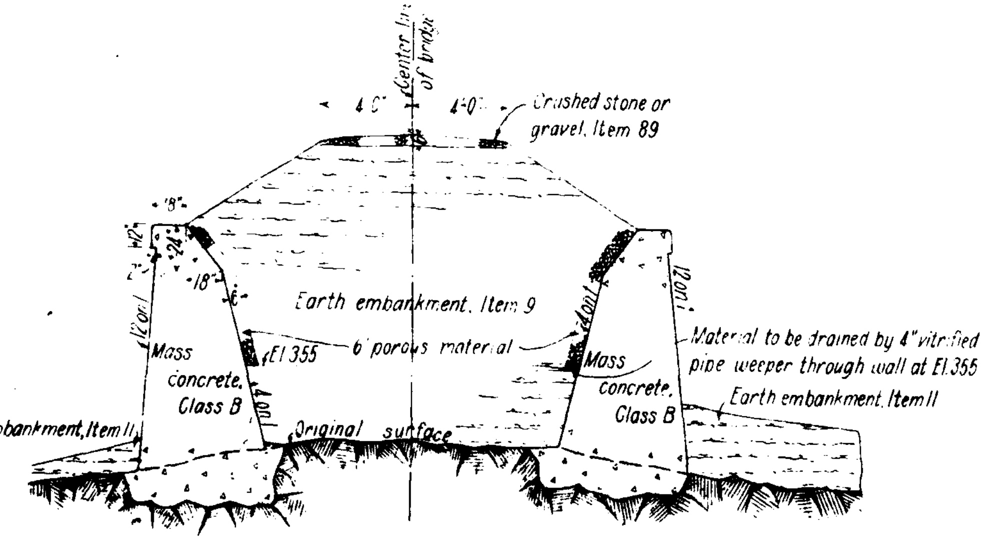
File Cont 9-3.44 KK Acc 15843

B-8

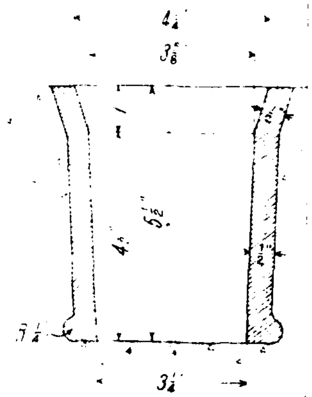


1. Location of sections shown on Sheet 22 B, Acc 15843
2. Notes 2, 3, 4 and 5 of Sheet 22 B, Acc 15843 apply to this sheet also

SECTION A-A



SECTION C-C



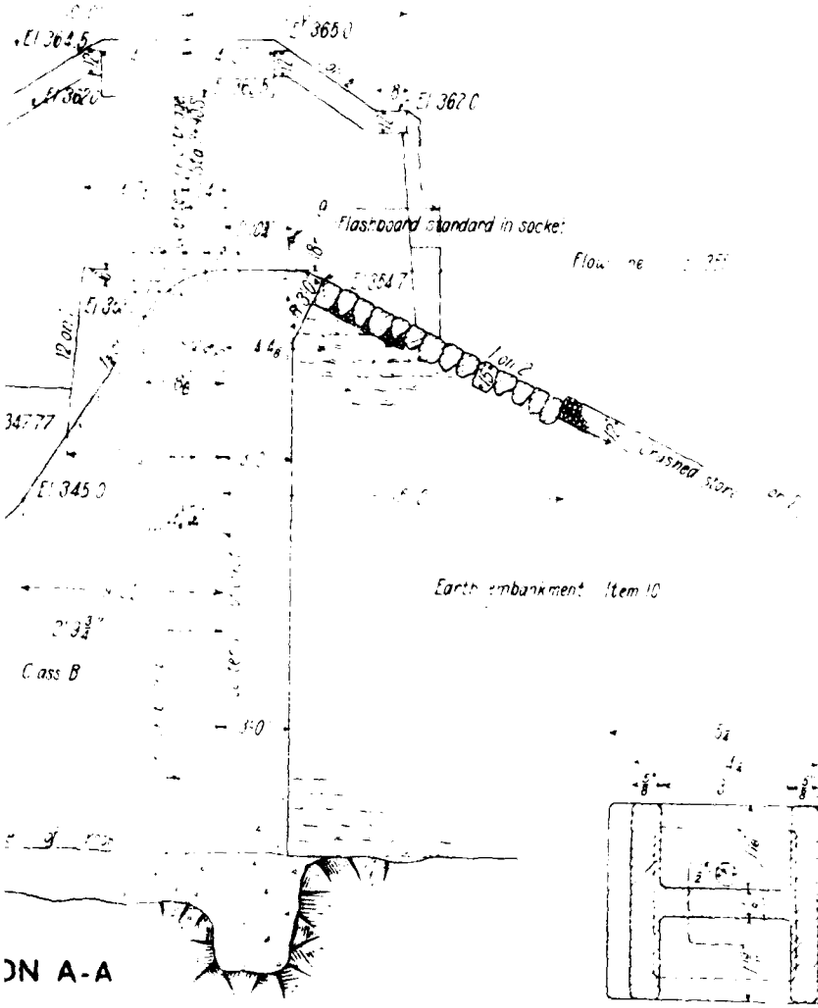
SECTION H-H

SOCKET FOR

Drawn A.G.P., 12-E-13
Traced W.F.
Checked W.M.A.Jr.
Fred F. Moore
Designing Eng.

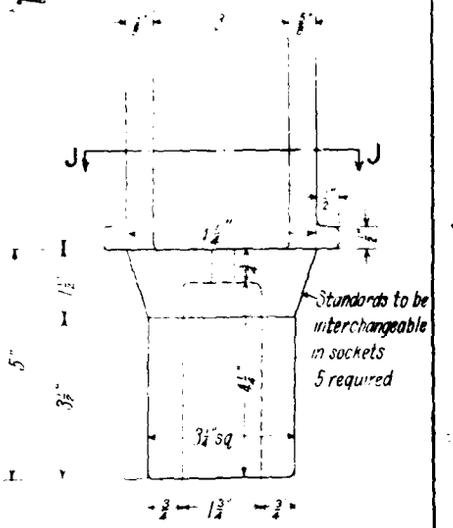
Ref - Acc 12457, 14147, 16378

CONTRACT 9 SHEET 22C
WORKING DRAWING



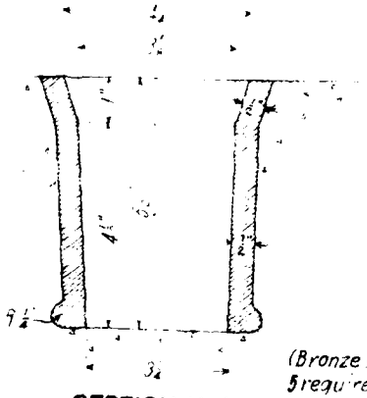
ON A-A

SECTION J-J

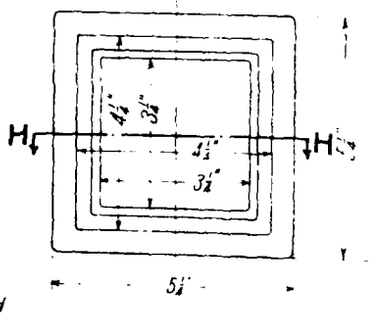


REMOVABLE STANDARD
(Cast iron)

0 1 2 3 4 5In



SECTION H-H



PLAN

(Bronze)
5 required

SOCKET FOR REMOVABLE STANDARD

0 1 2 3 4 5In

Dept Eng Hdqrs

Chief Eng

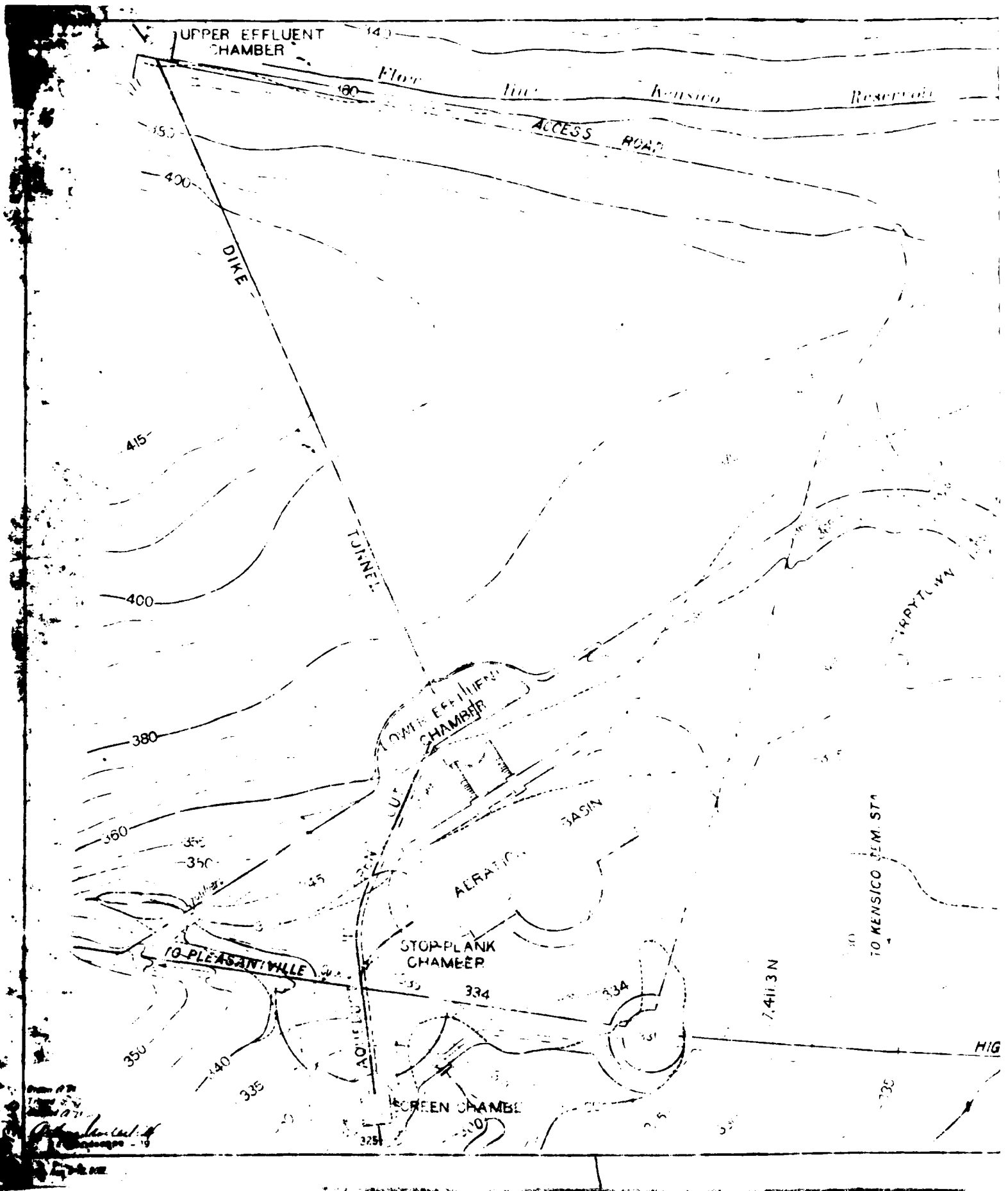
City of New York
BOARD OF WATER SUPPLY
KENSICO DAM
WASTE WEIR
CROSS-SECTIONS

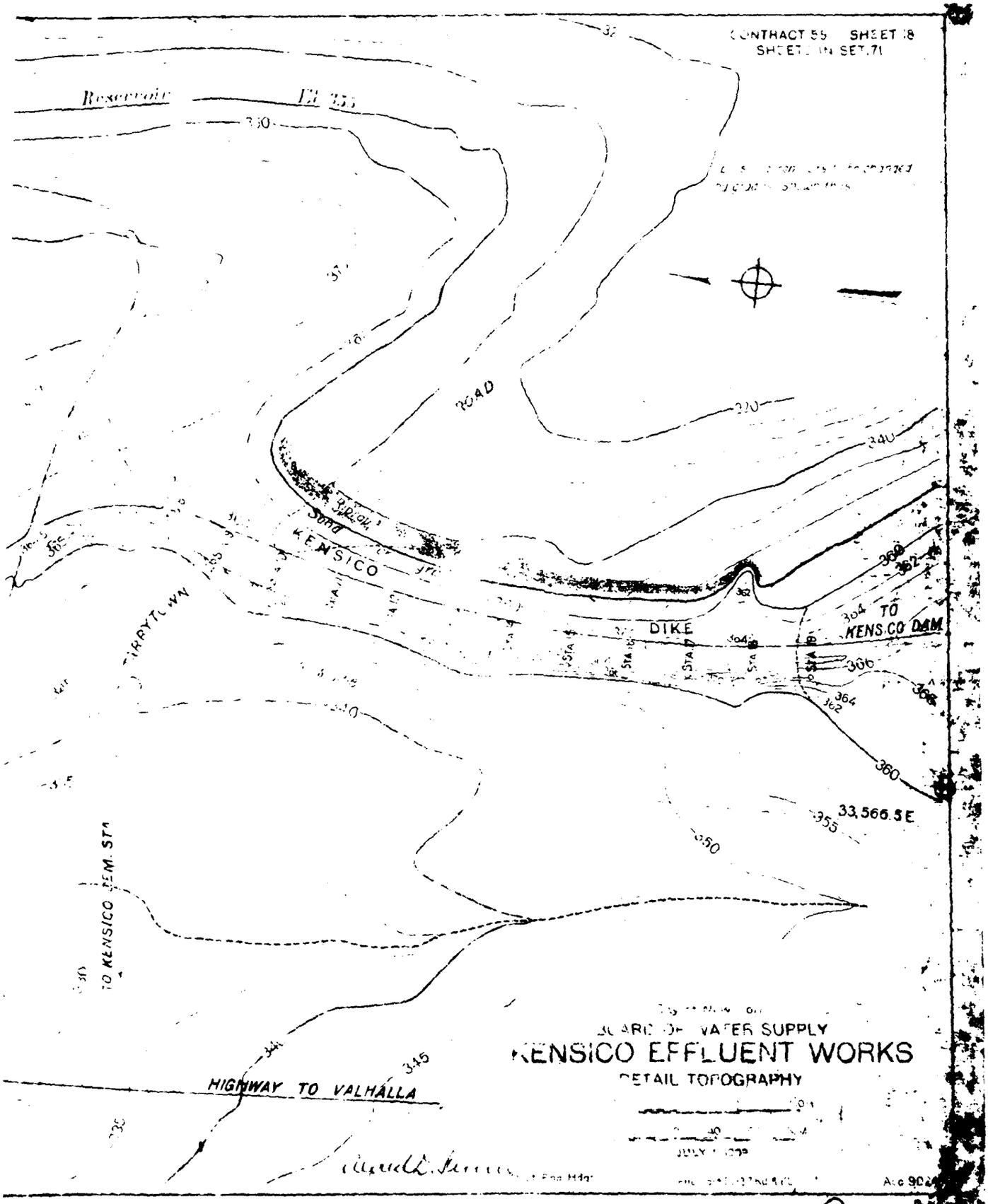
2 0 2 4 6 8 10Ft

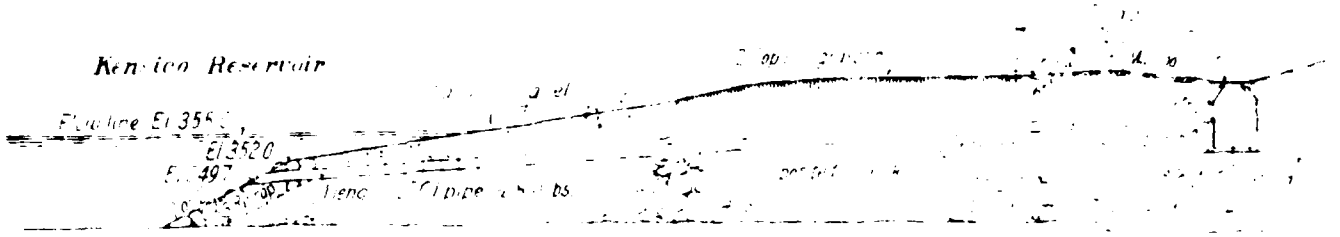
AUGUST 28, 1912

File Cont 9 · 3 44 KK Acc 15928

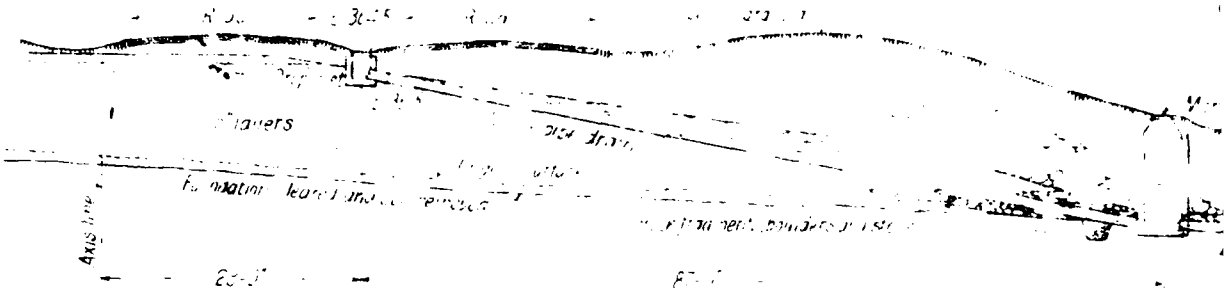
21 B-9


UPPER EFFLUENT CHAMBER
ACCESS ROAD
DIKE
TUNNEL
LOWER EFFLUENT CHAMBER
AERATION BASIN
STOP PLANK CHAMBER
TO PLEASANTVILLE
TO KENSICO PUMP STA.
SCREEN CHAMBER
HIGH
380
360
350
400
415
334

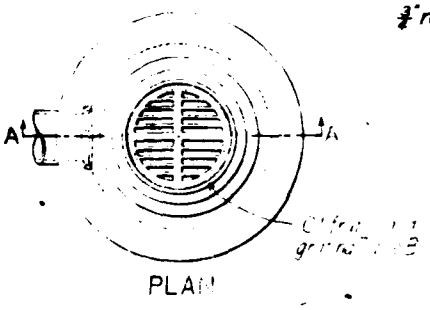

CONTRACT 55 SHEET 18
SHEET 1 IN SET 71
Reservoir El 355
330
340
350
360
304 TO KENSICO DAM
DIKE
KENSICO
HIGHWAY TO VALHALLA
TO KENSICO PEM. STA
33,566.5 E
BOARD OF WATER SUPPLY
KENSICO EFFLUENT WORKS
DETAIL TOPOGRAPHY
JULY 1939



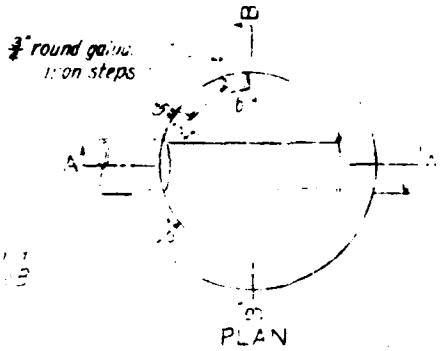
SECTION AT STA



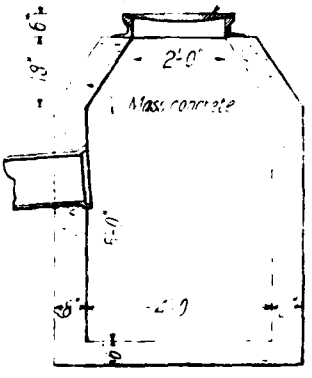
SECTION THROUGH DRAIN
SECTIONS THROUGH



PLAN

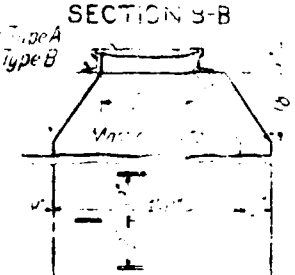


PLAN



SECTION A-A

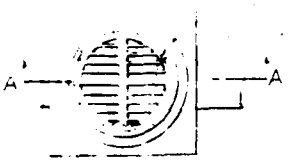
CATCH BASIN



SECTION B-B

SECTION A-A

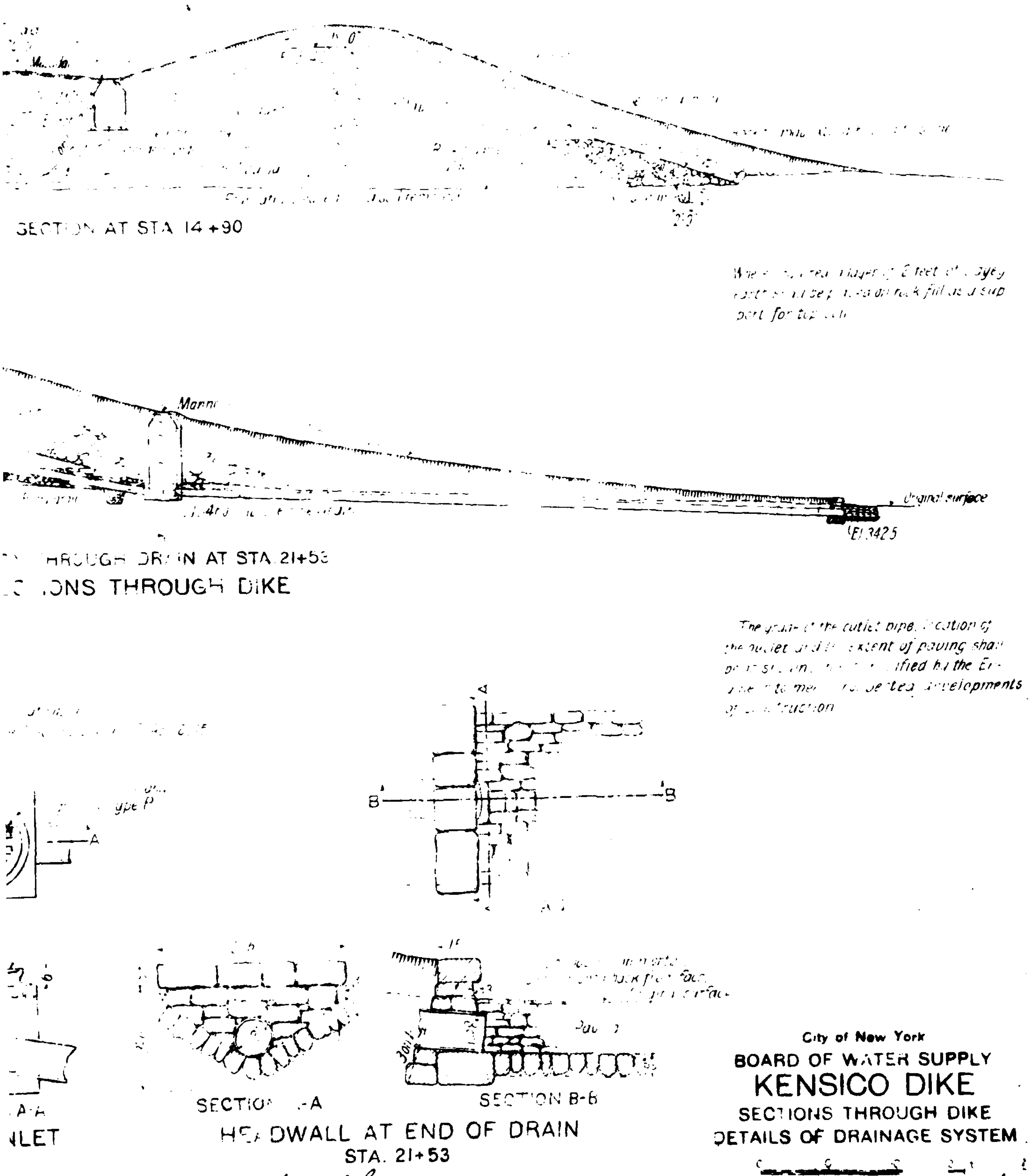
MANHOLE



SECTION A-A

DROP INLET

Designing Eng



City of New York
BOARD OF WATER SUPPLY
KENSICO DIKE
SECTIONS THROUGH DIKE
DETAILS OF DRAINAGE SYSTEM

MARCH 9, 1

Dept Eng

Chief Eng

File Cont 55-3.426

APPENDIX C
HYDRAULIC/HYDROLOGIC

KENSICO DAM

D-A-D RELATIONSHIPS *

AREA	DURATION	DEPTH	%
10 SQ MI	6 HRS.	26.2	107
10	12	30.2	123
10	24	33.3	135
10	48	37.1	151
10	72	38.8	158
200	6	17.8	72
200	12	21.0	85
200	24	24.6	100
200	48	27.9	113
200	72	29.1	118

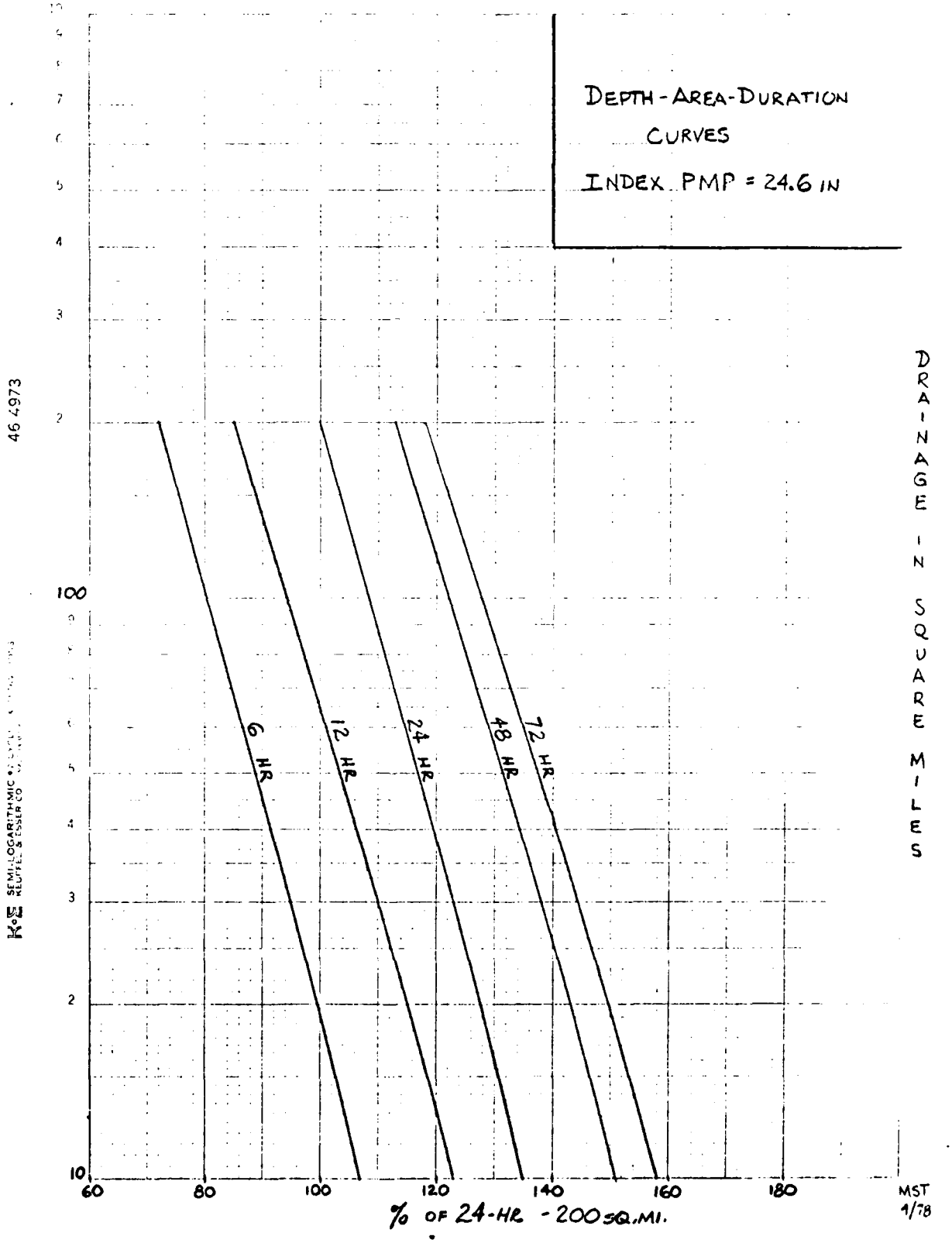
PMP INDEX RAINFALL - 24.6

RATIOS FOR OTHER DURATIONS

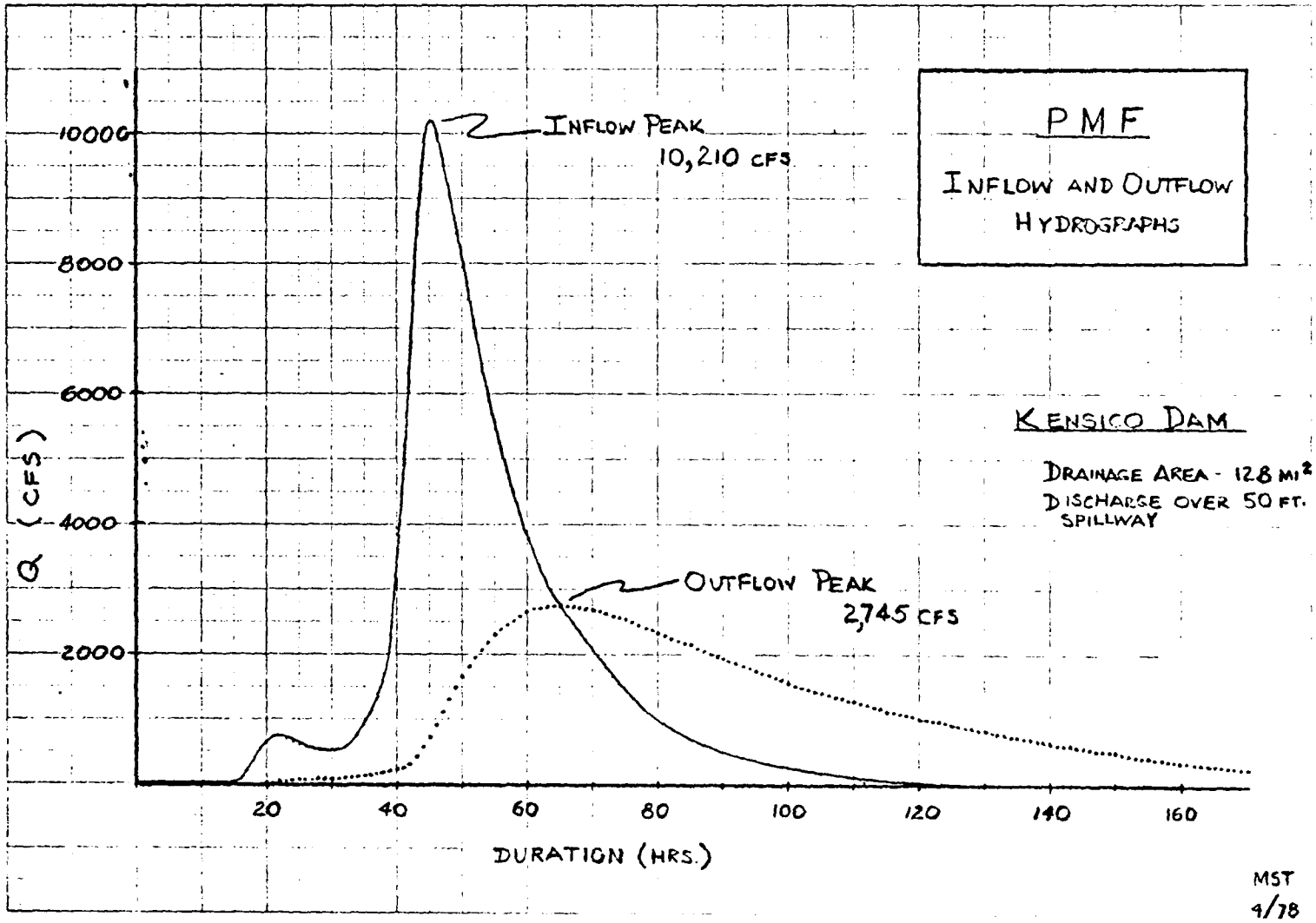
6 HRS	104.5
12	120.3
24	132.7
48	148.4
72	155.1

* from "Hydrometeorological Report No. 51"

MST
4/78


DEPTH - AREA - DURATION
CURVES
INDEX PMP = 24.6 IN
6 HR
12 HR
24 HR
48 HR
72 HR
DRAINAGE IN SQUARE MILES
% OF 24-HR - 200 SQ. MI.
MST
1/78
46 4973
SEMI-LOGARITHMIC
KEUFFEL & ESSER CO

C-2



MST
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E.2

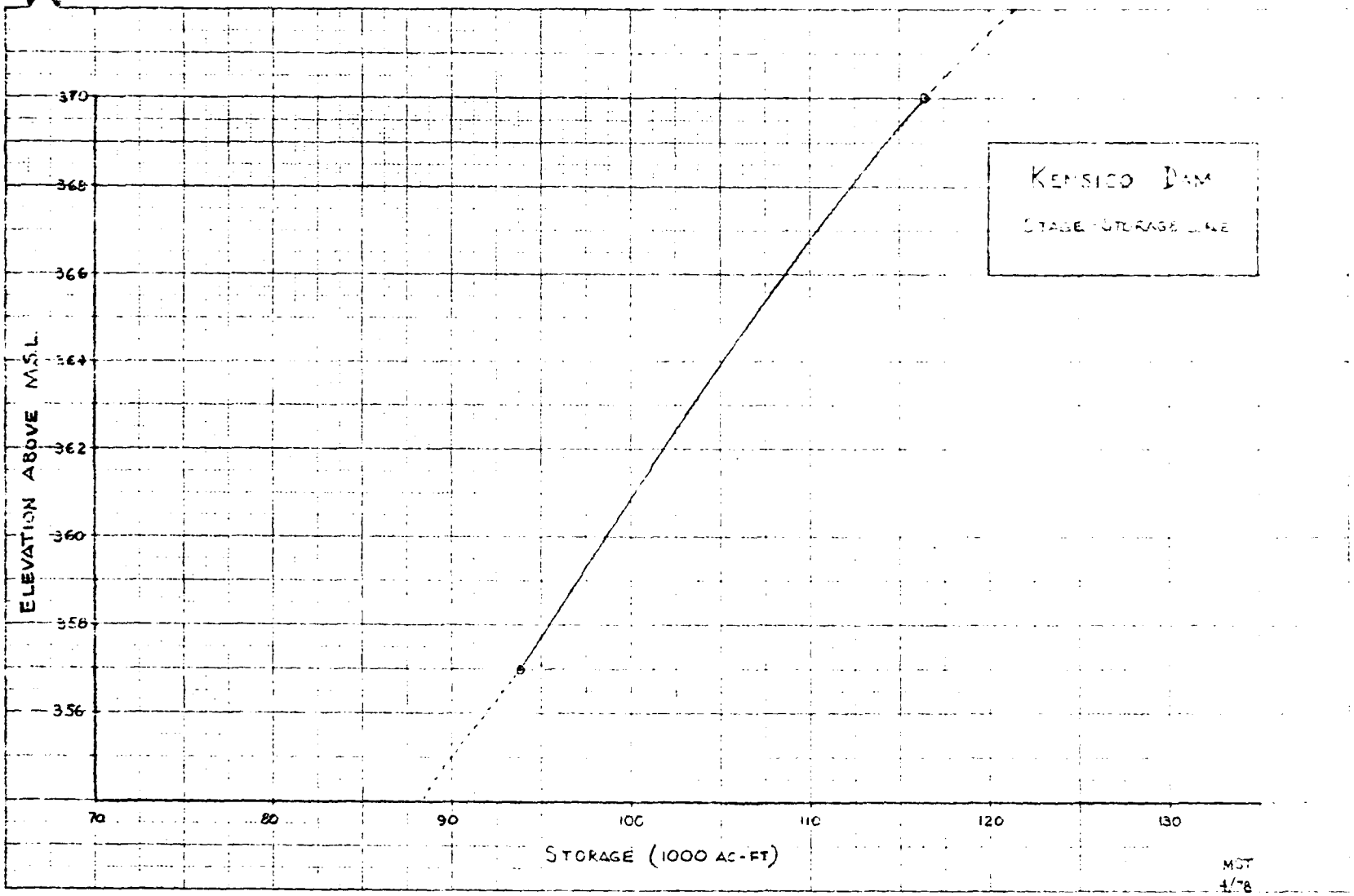
KENSICO DAM

SPILLWAY CREST LENGTH - 50 FT

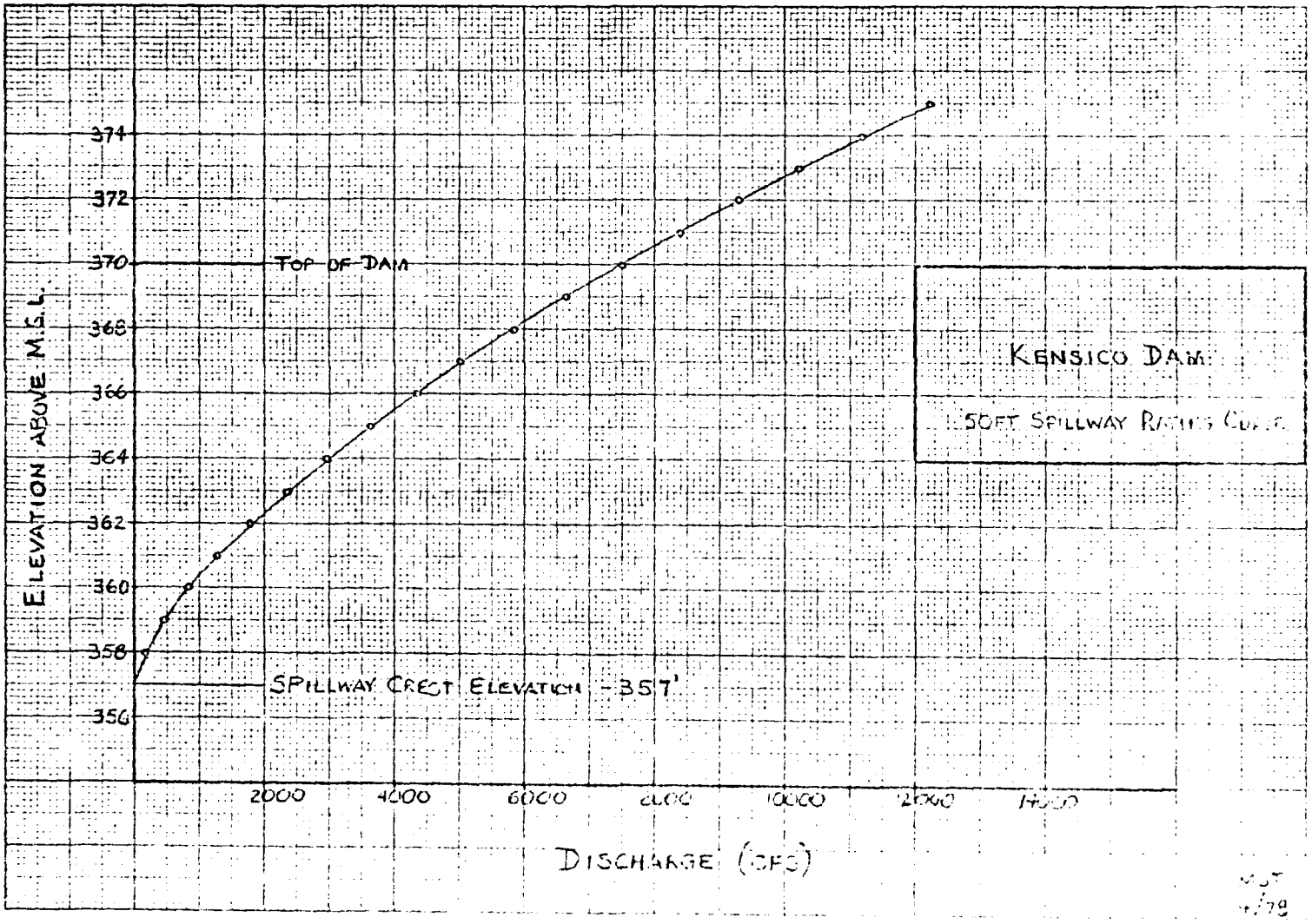
COEFFICIENT OF DISCHARGE - 3.2

	ELEVATION	HEAD	$H^{3/2}$	Q
SPILLWAY	357 FT	0	0	0
	358	1	1	160
	359	2	2.83	455
	360	3	5.20	830
	361	4	8.00	1280
	362	5	11.18	1790
	363	6	14.70	2350
	364	7	18.52	2965
	365	8	22.63	3620
	366	9	27.00	4320
	367	10	31.62	5060
	368	11	36.48	5840
	369	12	41.57	6651
TOP OF DAM	370	13	46.87	7500
	371	14	52.38	8380
	372	15	58.09	9295
	373	16	64.00	10240
	374	17	70.09	11215
	375	18	76.37	12220
	376	19	82.82	13250
	377	20	89.44	14310

MST
4/78


KENSICO DAM
STAGE - STORAGE CURVE
ELEVATION ABOVE M.S.L.
370
368
366
364
362
360
358
356
70
80
90
100
110
120
130
STORAGE (1000 AC-FT)
MST
4/78

S-2



C-6